BELL TELEPHONE QUARTERLY

VOL. XIII APRIL, 1934 NO. 2

NETWORK BROADCASTING

I. HISTORICAL SUMMARY

II. OPERATING THE NETWORKS

III. TELEPHONE FACILITIES

TEAMWORK AT ANDERSON, INDIANA

OWNERS OF THE BELL SYSTEM

INTERNATIONAL RADIO TELEPHONE CIRCUITS

AMERICAN TELEPHONE & TELEGRAPH CO. • NEW YORK

BELL TELEPHONE QUARTERLY

A Medium of Suggestion and a Record of Progress

CONTENTS FOR APRIL 1934

PAGE

Network Broadcasting

I. Historical Summary—*R. T. Barrett* 75

II. Operating the Networks—*E. V. Wallace* 98

III. Telephone Facilities—*G. S. Bibbins* 106

Teamwork at Anderson, Indiana—*Vance Oathout* 113

Owners of the Bell System—*C. S. Van Cise* 128

International Radio Telephone Circuits—*Elam Miller* 142

Notes on Recent Occurrences 150

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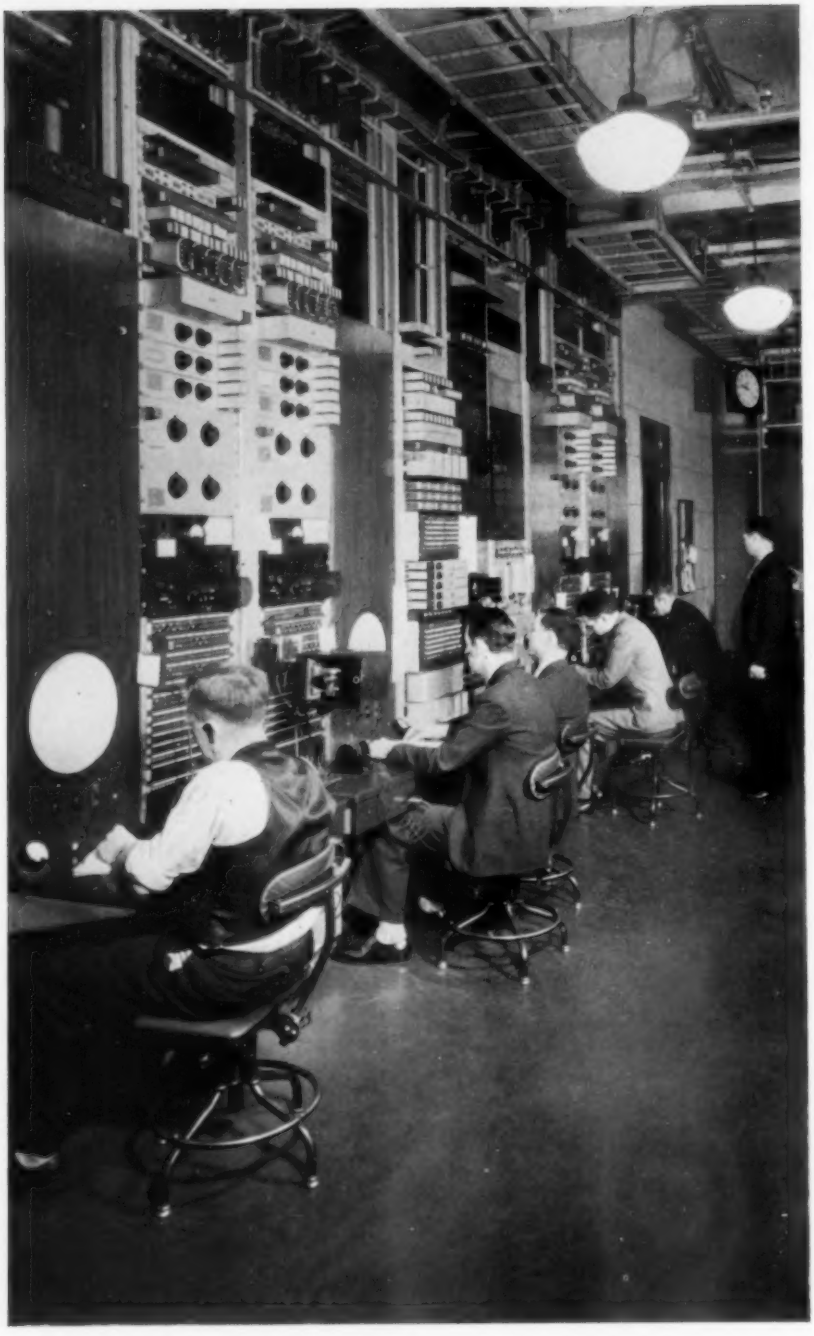


A Section of the Telephone Company's Main Switching Office in Chicago. Here, in the course of a week, as many as 600 switching operations take place in routing radio programs, as explained in the article which begins on the opposite page.

Network Broadcasting

I. Historical Summary

EARLY in the development of radio telephony it became apparent that it was ideally suited for what might be called wholesale communication—that is, for the broadcasting of entertainment and of educational or informative matter. This type of communication was essentially new. Signal fires, columns of smoke, the beating of a drum or the blowing of a trumpet had been used, it is true, for the general dissemination of information, but with such exceptions as these practically all previous forms of communication—whether by sign, signal, written message, telegraph, wire telephony or otherwise —were intended for use in what may be called person-to-person or point-to-point transmission of intelligence. The first extensive experimentation in radio telephony was along the lines of its development for this form of communication—that is, for the transmission of the spoken word across oceans, to ships at sea or to other inaccessible points to which it was not then practicable to provide wires, cables or other physical conductors. As early as 1915, engineers of the Bell System conducted a series of experiments in which radio telephone transmission was achieved from the United States to such distant points as Paris, France, and Honolulu, Hawaii. Out of these early experiments have grown the far-reaching systems of radio telephone channels which now provide regular telephone service between the United States and half a hundred other countries on six continents and the principal island groups.

Poulsen, Marconi, Fessenden, DeForest and others had early experimented with the transmission of music by radio telephone, with results that, in those pioneer days, were considered satisfactory. The first of the broadcasting stations which have

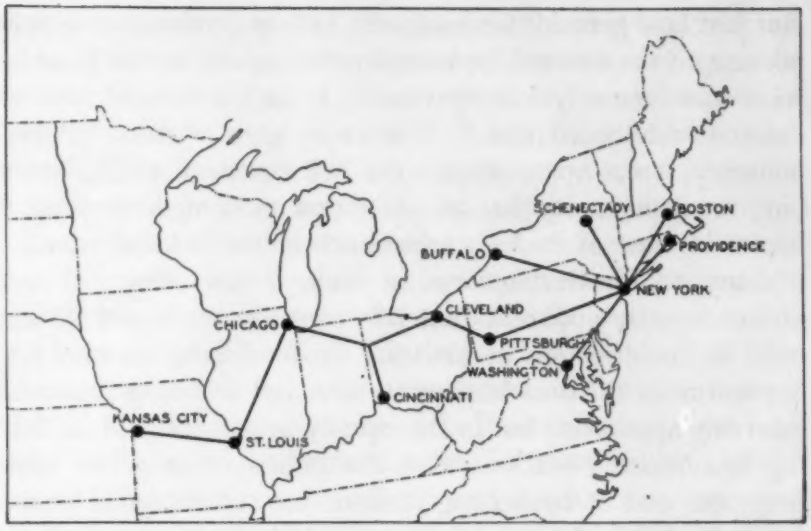
survived until the present was KDKA, Pittsburgh. This station presented its first regular program on Election Night, November 2, 1920, the broadcast consisting of a running account of returns announcing the election of President Harding.

Other broadcasting stations were opened at various points throughout the country. Originally, their programs consisted entirely of music, talks or other forms of entertainment originating within the studio of the broadcasting station itself. Somewhat later, some of the stations began to go to more remote points to "pick-up" programs of one form or another—music by hotel orchestras, church services, football games and other sporting events, political conventions and similar public gatherings. For this purpose, wire circuits were employed from the point of origin to the radio broadcasting stations.

It was at this point that the telephone companies first entered the field of radio broadcasting. It would have been technically possible, of course, for each broadcasting station to install its own circuits from the point where the program originated to its studio, but this would have proved unduly expensive. In many cases, however, local telephone companies already had circuits running to the points of origin, as well as to the broadcasting studios, and the necessary circuits could frequently be provided by connecting two such circuits to form a continuous link between point of origin and radio station.

Meanwhile, it had become apparent to the executives and engineers of the American Telephone and Telegraph Company, the headquarters company of the Bell System, that the development of radio telephony, and its quite obvious usefulness for this new form of communication, imposed upon the Bell System what was nothing less than an obligation to apply to its development the accumulated experience of years of research in the field of wire telephony.

Much that had been learned during the development of a telephone system which by this time was nation-wide in its reach would, obviously, be invaluable in the development of



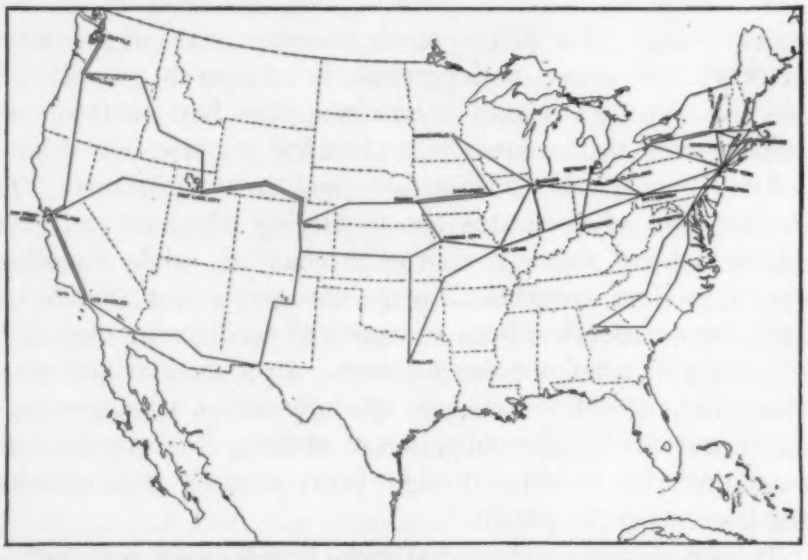
In 1924 It Was Considered a Major Accomplishment when Bell System Wires Connected Radio Stations in Twelve Cities for Broadcasting the Proceedings of the Republican National Convention.

radio telephony, both for point-to-point transmission and for broadcasting. The Bell System's intensive study of the characteristics of sound, and particularly of speech sounds; its research directed toward ascertaining the best methods of transforming these sounds into electrical impulses and transmitting them clearly over greater and greater distances; its development of apparatus for amplifying telephone currents which had lost strength, due to attenuation, while traveling over these long stretches of wire—this and a vast amount of other information had been accumulated during more than half a century of telephone development. In a peculiar and very true sense, the Bell System held this information as trustee, and was under the definite obligation of utilizing it in any field of communication in which it might prove valuable in advancing the interests of the public.

It soon became obvious that radio broadcasting was such a field—that there was a public need for this type of service.

But just how general this need was, or how pronounced or how permanent the demand for broadcasting service was to become, were questions as yet unanswered. If such a demand were to become widespread and if it were to give evidence of permanency, it was apparent that the Bell System would have not only an opportunity but an obligation to contribute what it could, in view of its long experience in the field of wire telephony, to the development of radio broadcasting. It was almost equally apparent that this contribution would lie not only in the direction of assisting in developing transmitting apparatus for the broadcasting stations and designing improved receiving apparatus, but in the equally important field of linking broadcasting stations with the points of origin of their programs and of connecting stations for simultaneous broadcasting—that is, for what later came to be known as chain or network radio service.

But the participation of the Bell System in any of these



THE SECOND NATIONAL DEFENSE DAY PROGRAM, JULY 4, 1925, FOUND TELEPHONE WIRES UNITING RADIO STATIONS FROM COAST TO COAST.

phases of the development of radio broadcasting could be justified only by a study of the public need, as indicated by public demand, for this type of service. If this demand was to be limited in extent, or to give evidence of a public interest which would have no permanency, the expenditure of effort or capital on radio broadcasting would be obviously unjustified.

In order to continue its research in radio telephone transmission, begun in 1915, the Bell System established, late in 1921, an experimental station known as 2XB. This was located at 463 West Street, New York City, at what is now the Bell Telephone Laboratories. About the middle of 1922, Station WBAY was put into operation at 24 Walker Street, New York City, and shortly thereafter Station 2XB was given the call letters WEAF. Stations WBAY and WEAF were operated for some time, until WBAY was abandoned and WEAF became the Bell System's only broadcasting station in New York. These Bell System stations were used, not alone for the pur-

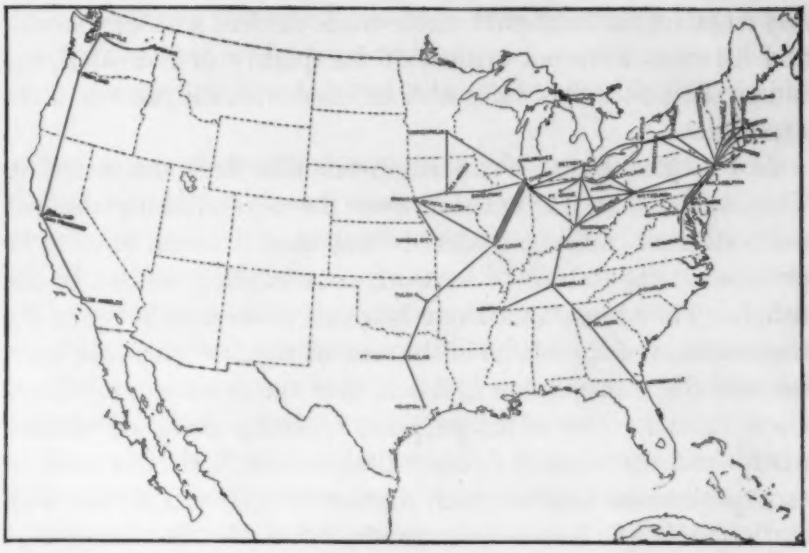
By the Time of the First Tunney-Dempsey Bout in 1927, Radio's Reach Had Been Extended to the Limits of the Country, North, South, East and West.

pose of continuing experimentation in radio telephone transmission, but for the not less important purpose of ascertaining the public reaction to radio broadcast programs of high quality. These stations became, in effect, laboratories in which were studied certain technical problems and the problem of public demand for radio broadcasting programs. After this experimental work had been completed, Station WEAF was sold to the Radio Corporation of America, ownership subsequently being transferred to the National Broadcasting Company.

Meanwhile, Bell System engineers and scientists had done a considerable amount of work which was to have a direct bearing upon the development of radio broadcasting, and particularly on the use of telephone circuits for program transmission. Before the actual development of radio broadcasting, much broadcasting had been done with the so-called public address systems, in which loudspeakers were used to cover large audiences. In many instances, the speech and music thus broadcast was transmitted over long distance telephone circuits, a notable example being the transmission of the ceremonies attending the burial of the Unknown Soldier on Armistice Day, 1921, when large audiences in New York and San Francisco, as well as that at Arlington, Va., were enabled to listen to the impressive program.

The apparatus and methods developed for use in connection with the public address systems were applied to the new field of radio broadcasting and proved to be invaluable contributions, since it also demanded high quality reproduction of speech and music.

An early instance of the combination of the public address system, long distance telephone lines and radio broadcasting was afforded by the reporting of a football game played in Chicago in the fall of 1922. By means of high quality transmitters and amplifiers located at the football field, announcements of the plays and the applause of the spectators were delivered to a cable circuit extending to the toll office of the



THESE WERE THE CHAIN BROADCASTING CIRCUITS REGULARLY FURNISHED BY THE BELL SYSTEM AT THE END OF 1927.

telephone company in Chicago. This circuit was connected there to a toll line to New York, where it delivered the telephonic currents to a radio broadcasting transmitter. In Park Row, New York, a truck was provided with a radio receiving set which was arranged to operate a public address system. In this experiment the factors involved were essentially those which characterize modern chain or network broadcasting: a source of the program; suitable apparatus for picking it up; a telephone circuit connecting this source with the radio broadcasting station; the transmitter at the latter station; and, finally, the listener's receiving set.

Early in the following year, station WEAF was to participate in experiments which more closely suggested the linking of two or more broadcasting stations for the transmission of the same program.

The first of these experiments took place in January, 1923, when a special telephone talking circuit joined Station WEAF with Station WNAC, Boston. As radio receiving sets of that

day were, for the most part, home-made devices with ear phones, and listeners were not critical of the quality of reception, the radio public as a whole was well satisfied with the success of the experiment.

Not so the Bell System engineers who had conducted it. They knew that transmission over the wires linking the two radio stations could be bettered—and that it would have to be bettered if the future of network broadcasting was to be assured. They knew that there is a vast difference between the transmission of speech, as in the case of regular telephone service, and the transmission of music over the same wires. They knew that, for the latter purpose, specially designed circuits would have to be used. They designed such circuits and, in an experimental test in which Station WEAF was linked with Station WMAF, South Dartmouth, Mass., in the summer of 1923, they put such a specially designed circuit into operation. The special apparatus required for the test was removed after the completion of the experiment, but with this "hook-up" the history of modern chain or network broadcasting began.

For it has been—in America, at least—the linking of broadcasting stations by a far-reaching web of telephone wires that has made radio broadcasting what it is today. Not otherwise could the hundreds of broadcasting stations which serve the nation—many of them in small cities, remote from the larger centers of population—have tapped the supply of artistic talent of which they are now giving their listeners the benefit. In no other way could football games and other sporting events, the proceedings of political conventions and other public gatherings, or the voice of a President, speaking from his study in the White House, be brought to the millions of American radio sets. Technical and economic limitations alike would have prevented the evolution of radio broadcasting into anything like the high degree of development it has reached in the United States, were it not for thousands of miles of telephone wire. Stretching from coast to coast and from Canada to Mexico,

these telephone circuits have been utilized in binding radio stations together into groups and, as occasion demands, uniting these groups into a single network that is nation-wide in its extent.

At important centers throughout the country, as at New York, Chicago, and San Francisco, so-called "control points" have been established and constitute the nerve centers of the 88,000 miles of wire regularly used by the eleven basic networks. Scores of other telephone buildings house the complex apparatus required for this form of service. These thousands of miles of wire are carefully watched over by specially trained employees totalling between 400 and 500 men.

The part which the telephone plays in making possible the far-reaching radio broadcasting networks which serve America's millions of listeners has been summarized by an officer of one of the large broadcasting companies as follows:[1]

> It is to the telephone, not to radio, that we owe the development of the equipment whereby speech and music are made available for broadcasting.
>
> More than this, it is the telephone wire, not radio, which carries programs the length and breadth of the country. John Smith, in San Francisco, listens of a Sunday afternoon to the New York Philharmonic Orchestra playing in Carnegie Hall. For 3200 miles the telephone wire carries the program so faithfully that scarcely an overtone is lost; for perhaps fifteen miles it travels by radio to enter John Smith's house. And then he wonders at the marvels of radio!
>
> But what about programs from overseas? Here, indeed, wireless telephony steps in, but not broadcasting in the ordinary sense. The program from London is telephoned across the Atlantic by radio, but on frequencies entirely outside of the broadcast band.
>
> Broadcasting, then, is the child of the telephone; in America it is certainly the child of the American Telephone and Telegraph Company. The whole structure of commercial chain broadcasting as we know it today has grown out of the pioneer work done prior to 1926. Telephony has largely created the mechanism of broadcasting.

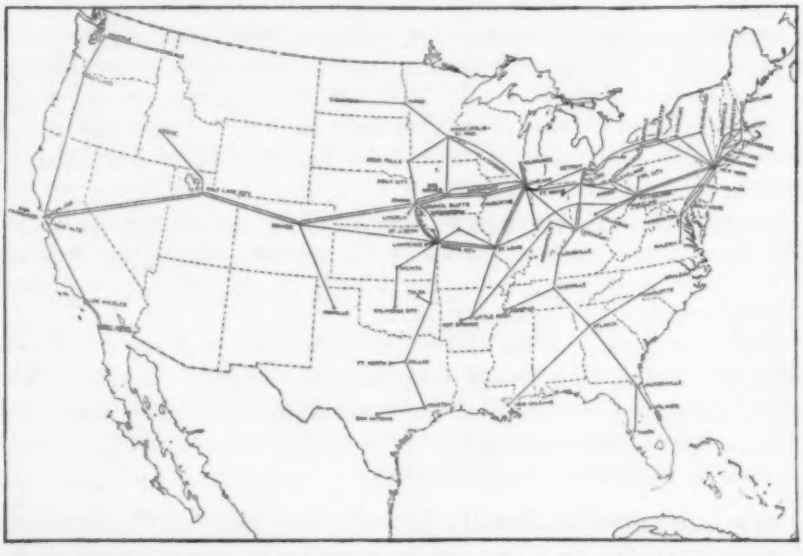
It is quite possible that the hypothetical John Smith, to whom this writer refers, may be aware that the program to which he

[1] "Broadcasting: a New Industry," *Harvard Alumni Bulletin*, December 18, 1930.

is listening in San Francisco has not been carried across the continent by radio. But it is also quite possible that his information on the point does not extend far beyond the vague notion that in some way that he does not understand, "it is done by telephone wires." And to John Smith, and millions like him, a telephone wire is a telephone wire, and that is the end of the matter.

But it is not the end of the matter for the engineers of the American Telephone and Telegraph Company. They have learned from long experience that the technical problems involved in the provision of circuits for the broadcasting networks are quite different from those confronted in the provision of commercial telephone service, with which the Bell System organization has long been thoroughly familiar and for which its plant and equipment have been designed.

From the days when Alexander Graham Bell conducted the first of the experiments which led to his invention of the tele-



ON THE NIGHT BEFORE THE 1928 PRESIDENTAL ELECTION, BELL SYSTEM CHAIN BROADCASTING CIRCUITS SERVED A COUNTRYWIDE LINE-UP OF STATIONS.

phone, he and his successors of the organization which bears his name have been students of sound and of its electrical transmission. When confronted with the problem of providing circuits for network radio broadcasting, they knew, from more than half a century of experience, that this problem involved factors not encountered in the provision of regular, commercial telephone service.

Telephone wires had, it is true, been used as early as 1877, the year following the invention of the telephone, for the transmission of music. In order to arouse public interest in the telephone, Bell gave demonstrations or lectures in various cities of the East, and one of the features of these was the transmission of songs, cornet solos, cabinet organ and similar musical selections from some outside point to the auditorium in which the lecture was held. In the light of present knowledge of the telephone art, however, it is perhaps safe to assume that these demonstrations, though they amazed the audiences which heard them, were reminiscent of Dr. Samuel Johnson's comment on the performance of a dog which he had seen dancing on its hind legs. The good doctor remarked, it will be remembered, that the spectacle was extraordinary—" not because the dog danced particularly well, but because it danced at all."

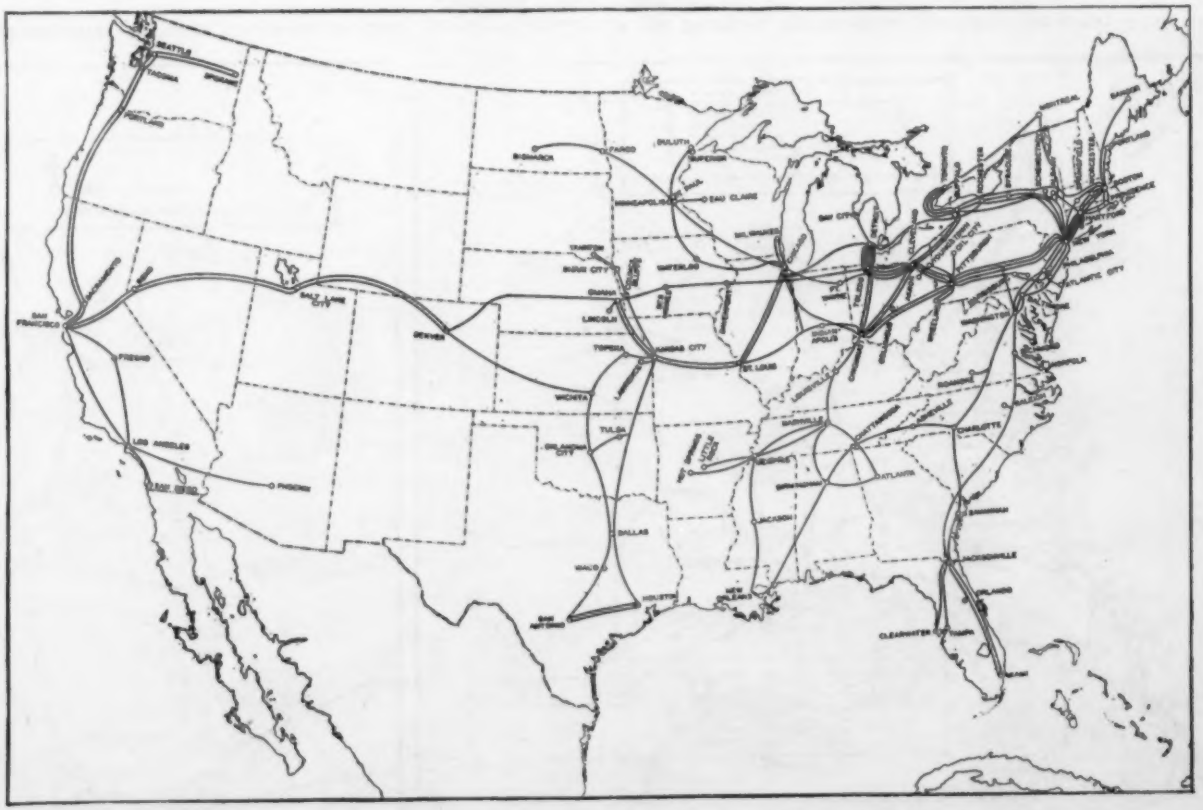
Imaginative writers—and artists, for that matter—of the early days of the telephone, delighted in predicting the time when entire audiences, as well as individual telephone subscribers, would be entertained by opera and orchestra programs transmitted over the wires. The truth is that music carried by wire, in the pioneer days of telephony, was hardly more than sufficiently faithful in its reproduction to be recognizable as music. As an entertainment feature, its attraction lay in novelty rather than in esthetic beauty.

Since these early days, telephone instruments and circuits have been much improved. The telephone today is quite adequate for transmitting speech which can be clearly and easily understood. Even today, however, regular telephone circuits

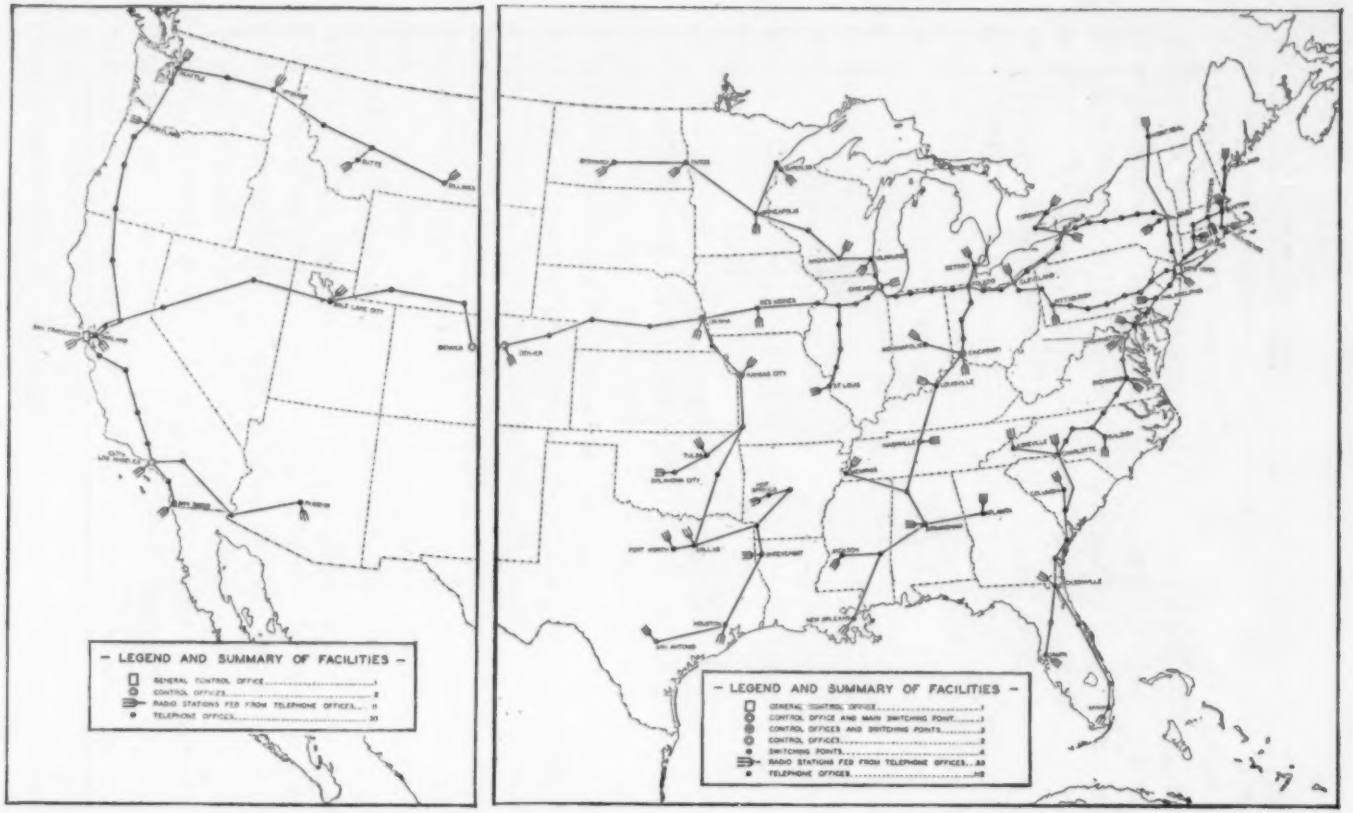
are not adequate for transmitting musical selections or other entertainment programs. There are sound technical reasons for this. For every-day telephony, the prime requirement is ability to transmit messages easily and accurately and at reasonable cost. The transmission of music and other sounds for entertainment purposes, however, involves much more severe technical requirements than the satisfactory transmission of speech for message telephone service, in order to maintain, for example, the aesthetic values involved in the reproduction of high grade music. In order to meet the qualities demanded for program transmission, it has been necessary for Bell System engineers to develop and provide special circuits quite different in their characteristics from ordinary telephone circuits. Their inherently higher cost is justifiable because of the fact that, in broadcasting, a single circuit is shared by many listeners.

Take the matter of frequency range, for example. For every-day telephony, circuits which will transmit a frequency range of somewhat more than three octaves, starting with middle C, give a high degree of intelligibility so that ideas can be easily and accurately interchanged. Circuits for entertainment purposes, however, require that a range of frequencies more than twice as wide as this be transmitted. The higher frequencies transmitted over these circuits add to the "brilliancy" of music, since more of the high-pitched notes and important overtones are transmitted. The lower frequencies give "body" to the reproduction. Transmitting these higher and lower frequencies, in other words, reproduces the programs much more naturally, so that nice distinctions between sounds of various musical instruments are preserved.

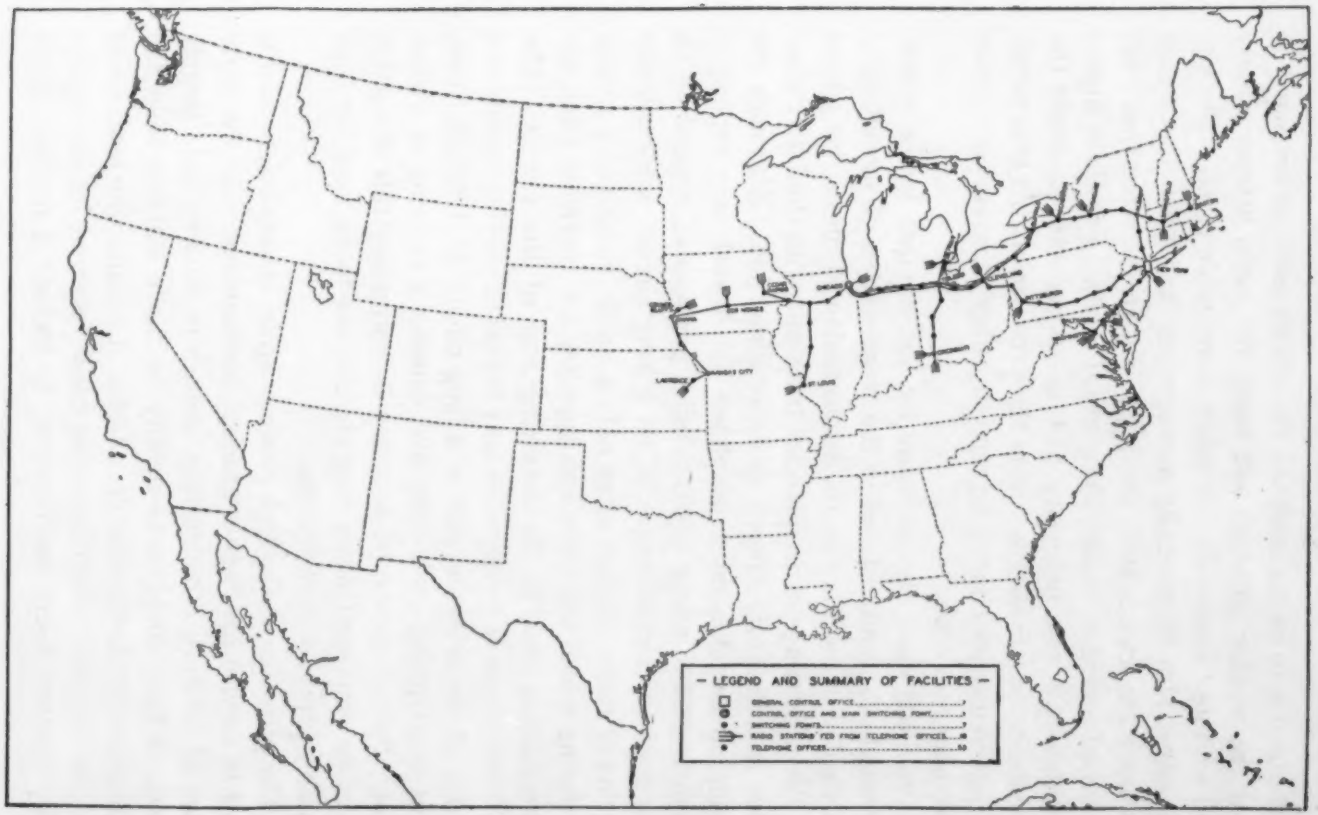
Circuits used for radio program transmission must also be so designed as to take care of a considerable variation in volume or loudness. In an ordinary telephone conversation, the range of variation in volume is relatively small. When, however, a musical selection, as, for example, a concert by a symphony



PROGRAM TRANSMISSION NETWORKS PROVIDED BY THE BELL SYSTEM AS OF MARCH 15, 1931.


– LEGEND AND SUMMARY OF FACILITIES –
GENERAL CONTROL OFFICE 1
CONTROL OFFICES 2
RADIO STATIONS FED FROM TELEPHONE OFFICES 11
TELEPHONE OFFICES 30
– LEGEND AND SUMMARY OF FACILITIES –
GENERAL CONTROL OFFICE 1
CONTROL OFFICE AND MAIN SWITCHING POINT 1
CONTROL OFFICES AND SWITCHING POINTS 2
CONTROL OFFICES 2
SWITCHING POINTS 4
RADIO STATIONS FED FROM TELEPHONE OFFICES .. 83
TELEPHONE OFFICES 113

RADIO BROADCASTING STATIONS CONNECTED BY BELL SYSTEM CIRCUITS FOR THE NATIONAL BROADCASTING CO. (RED NETWORK, RIGHT; ORANGE NETWORK, LEFT) EARLY IN 1934.



RADIO BROADCASTING STATIONS CONNECTED BY BELL SYSTEM CIRCUITS FOR THE NATIONAL BROADCASTING CO. (BLUE NETWORK) EARLY IN 1934.

orchestra, is to be transmitted, the circuit must be arranged so that the weaker passages will reach the radio listener clearly and without "cross-talk" or other undesirable noise. The circuit must also be specially arranged so that when the higher volumes are transmitted, the apparatus in the circuit will not overload and thus distort the musical tones. For these higher volumes it is also necessary to take special care to avoid the possibility of "crosstalk" from the program circuit into paralleling circuits which may be carrying other programs or regular telephone messages.

Provision must also be made for still another factor which, although also encountered in the transmission of speech, is of particular importance in the transmission of music, by reason of the wide range of frequencies transmitted in the latter case. This is technically known as delay distortion. Although the electrical currents on a telephone line travel very rapidly—from 10,000 to about 180,000 miles per second, depending on the type of circuit—there is, on a long circuit, a measurable period of time—though often only a small fraction of a second—during which the electrical impulses are traveling from the transmitting end to the receiving end of the circuit. The different tones or frequencies may travel at varying speeds and arrive at the receiving end of a long circuit at different times, thus overlapping each other and causing a blurring or distortion. Special means of avoiding or correcting this distortion must be employed when long circuits are to be used for high quality program transmission.

The provision of the high grade program transmission circuits now in service has been a gradual development. In the early days of network broadcasting, open-wire circuits were largely used, as they could more readily be made suitable than the cable circuits then available. Later, it became the practice of the Bell System, when installing cable required for its regular long distance telephone business, to include a number of 16

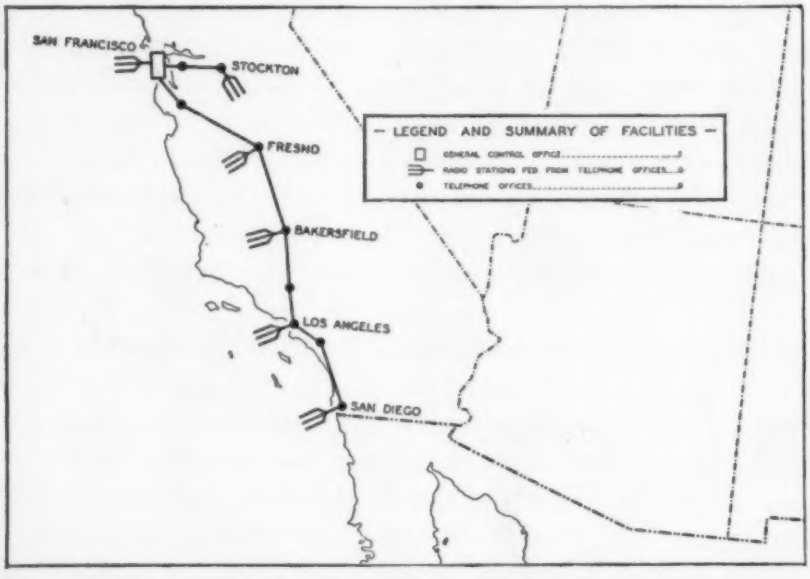
— LEGEND AND SUMMARY OF FACILITIES —
GENERAL CONTROL OFFICE 1
CONTROL OFFICES AND SWITCHING POINTS 4
CONTROL OFFICES 3
SWITCHING POINTS 4
RADIO STATIONS FED FROM TELEPHONE OFFICES 69
TELEPHONE OFFICES 147

RADIO BROADCASTING STATIONS CONNECTED BY BELL SYSTEM CIRCUITS FOR THE COLUMBIA BROADCASTING SYSTEM (PURPLE NETWORK) EARLY IN 1934.

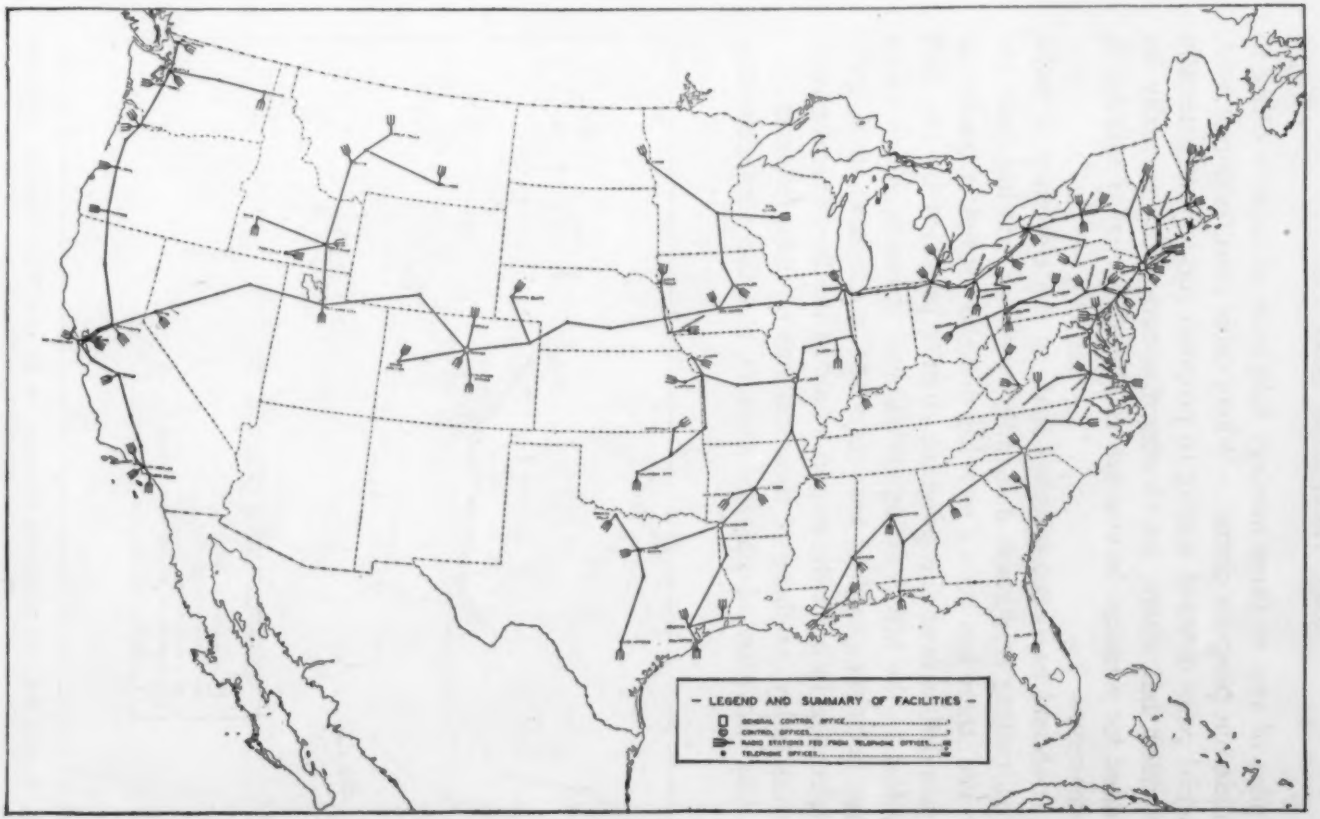
gauge pairs specially located in the cables which were reserved for use in providing radio network facilities.

In addition to providing these special conductors, it is necessary to provide special forms of amplifying equipment or repeaters, capable of taking care of the wide range of frequencies to be transmitted. Various other forms of supplemental apparatus, including special loading coils, are also required.

Whenever a circuit is removed from regular message service and transformed into a program circuit, the change involves the loss, not only of the two physical wires which make up the circuit, but of other circuits which might otherwise be operated simultaneously with the regular telephone circuit on this same pair of wires. Thus, on open wires, a change from message to program service means giving up the use of the same conductors for telegraph messages which would ordinarily be transmitted simultaneously with the telephone messages and often the sur-



BELL SYSTEM HOOK-UP FACILITIES PROVIDED FOR DON LEE IN THE SPRING OF 1934.

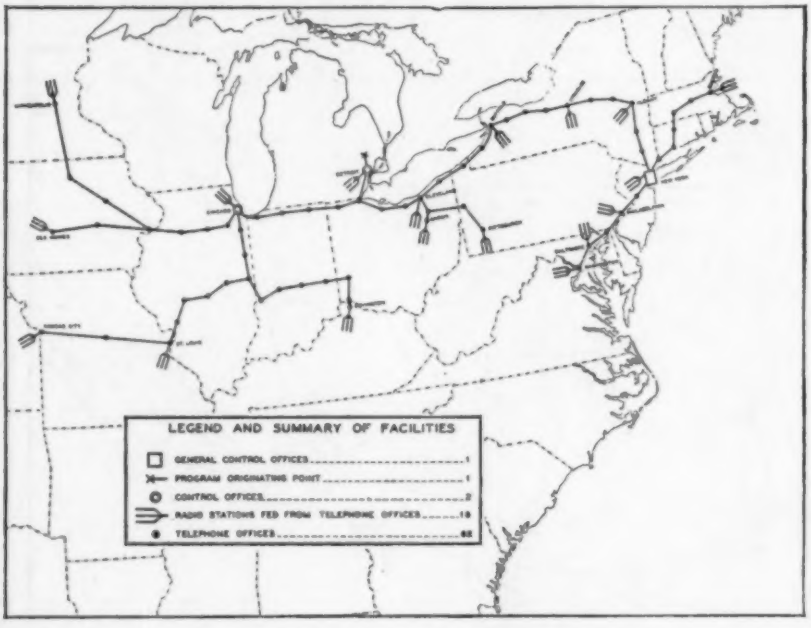


RADIO BROADCASTING STATIONS TEMPORARILY CONNECTED BY BELL SYSTEM CIRCUITS FOR THE PEOPLE'S PULPIT ASSOCIATION IN OCTOBER, 1933.

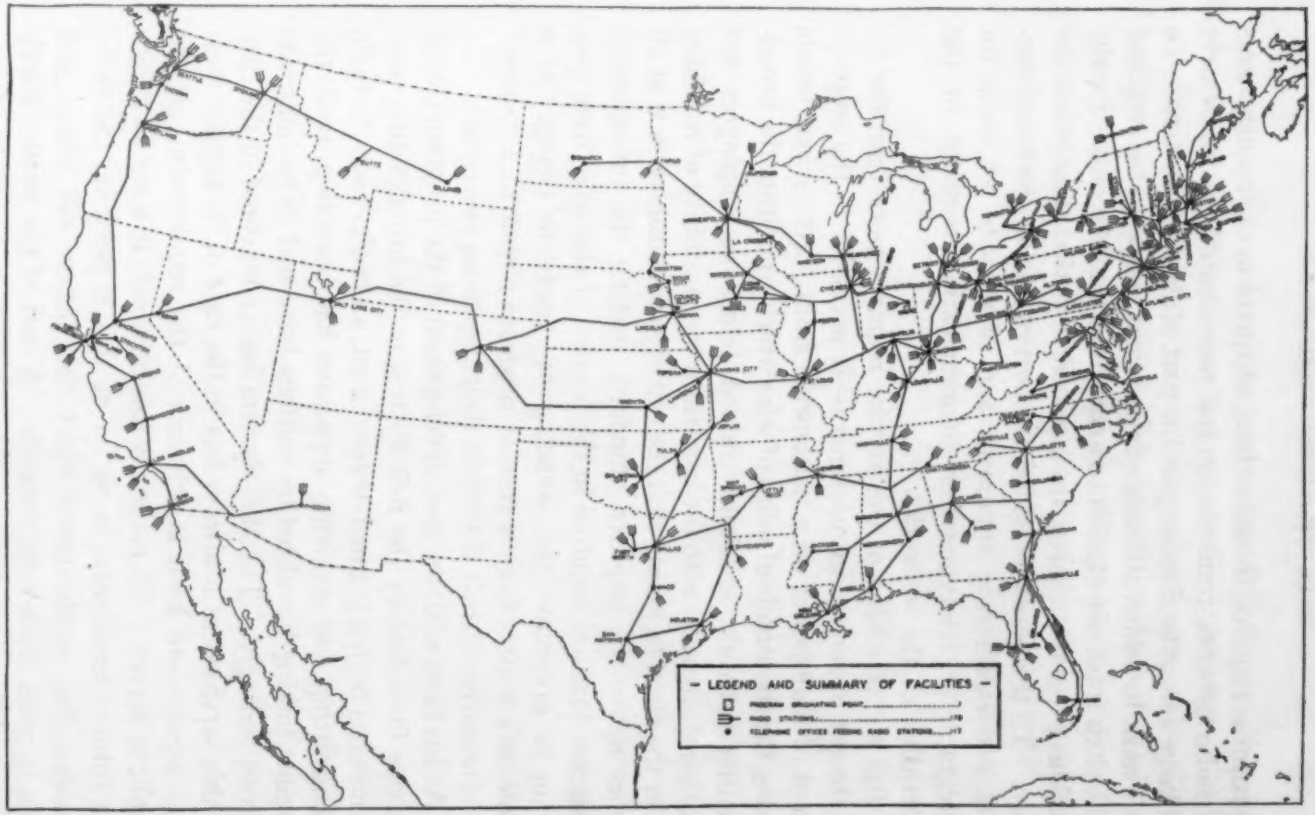
render of two or three message telephone circuits in order to obtain one program circuit. Where cable construction is used, special pairs devoted wholly to program service are generally provided, but where, for shorter distances, pairs normally intended for message service are employed, a similar sacrifice is necessary.

It should be borne in mind that, as the efficiency of radio broadcasting equipment and radio receiving sets has been improved, there has been a growing demand for better quality of transmission over the program circuits provided by the Bell System to the broadcasting companies. Circuits which might have been acceptable a few years ago would now prove quite inadequate to meet the requirements of the broadcasting companies today, or those of their millions of radio listeners.

The provision of physical circuits and the supplementary


LEGEND AND SUMMARY OF FACILITIES
GENERAL CONTROL OFFICES 1
PROGRAM ORIGINATING POINT 1
CONTROL OFFICES 2
RADIO STATIONS FED FROM TELEPHONE OFFICES 19
TELEPHONE OFFICES 62

BELL SYSTEM HOOK-UP FACILITIES PROVIDED FOR STATION WJR, DETROIT. (YELLOW NETWORK—FATHER COUGHLIN.)



SPECIAL HOOK-UP OF STATIONS IN CONNECTION WITH COUNTRYWIDE CELEBRATION OF PRESIDENT ROOSEVELT'S BIRTHDAY, JANUARY 30, 1934.

apparatus required to make them adequate to the requirements of radio network transmission has necessitated the investment of large amounts of money on the part of the Bell System. To this must be added still other investment in apparatus required to switch from one station to another as the "layouts" for the various programs change from period to period throughout the day. To this must be added the cost of various forms of control and monitoring apparatus and of circuits set aside for telegraph or teletypewriter communication required in the operation of the networks.

But the provision of this service requires more than the investment of money in machinery—it necessitates the employment of man-power on a nationwide front. At various points along the thousands of miles of wire which constitute the broadcasting network, specially trained telephone employees are stationed, charged with the important responsibility of watching over the circuits, seeing that the quality of transmission is at all times up to the required standard, making the innumerable switches that are required in the routine of changing from program to program—and standing by, ready to change, at a moment's notice, from a regular program circuit to a "spare" or alternative circuit if trouble develops in an emergency.

As has been said, the past development of the program circuit service furnished by the Bell System to the broadcasting companies has been a gradual development, an evolution. As radio transmitting and receiving apparatus has been improved, the circuits linking broadcasting stations have had to be improved correspondingly. The Bell System has endeavored in the case of this service—as it always has in the case of its regular message service—to keep in advance of the requirements of the public it serves. To maintain this advance, it must look into the future; anticipate, in so far as this is possible, the radio broadcasting requirements which this future will bring; and plan to meet these requirements. A part of the service which it is providing to meet the needs of the present consists of pre-

paring for the needs of the future and of making a reasonable investment to this end.

Money, mechanisms, men—these are the elements which lie behind the provision of the telephone circuits required to make possible radio broadcasting as America knows it today. They are the fundamentals upon which has been built, in response to a public need, a far-reaching public service.

R. T. BARRETT

Network Broadcasting

II. Operating the Networks

TO operate the circuits required for program transmission demands the specialized knowledge and experience of hundreds of telephone employees. The individuals making up this group are scattered in every part of the country. Yet so close is the coördination of the group that to all intents and purposes they might be working in the same room.

Perhaps the best method of giving an accurate picture of their activities is to describe the hour-to-hour detail of the operation of a network throughout the period of a typical day. To this end, networks comparable to those in actual operation are discussed in the following paragraphs.

The networks, for simplicity, will be designated A and B. The key station for both networks is New York, but a fairly large number of programs originate in Chicago. The insert facing page 100 gives the layout of each network and shows the six main switching centers where the Telephone Company's forces perform switching for the broadcaster. These networks are in service sixteen continuous hours daily, from 8 A.M. to 12 midnight under normal operation, with such overtime service as may be desired.

New York, designated as the General Control office, is responsible for satisfactory maintenance of service and execution of all orders received from the broadcaster. A general view of a section of this office is shown in Figure 1. The equipment in this office is devoted solely to program transmission service. The photograph shows less than half the equipment in the office. To facilitate efficient handling of emergency matters, and to improve service maintenance, certain duties are delegated to other offices known as Control offices. For

the networks under consideration, Washington, Cincinnati, Buffalo, Chicago, Kansas City, Denver and San Francisco are control offices for the sections extending south and west of each, respectively, to the next adjacent control office. New York also functions as the section control office for each network between New York and Chicago, New England, and sections south to Washington. Each control office is connected with all intermediate amplifier offices in its section by telegraph circuits. The general control office keeps in touch with each control or switching office through a teletypewriter circuit and is connected with certain strategically situated offices by a special "express" telegraph circuit for speed in handling emergency cases.

Now let's start our 24-hour day at 1:30 A.M., when all service is "good-night." Preparation for the start of service for another day must be completed prior to 6:45 A.M., at which time the "Morning Exercises" program must be transmitted over network B to nine stations located in New England, New York, Ohio, Pennsylvania, Ontario, and the District of Columbia. Before the daily routine circuit line-up testing can start, usually certain general maintenance work must be done. Today, for example, amplifier tube tests are to be made at all offices between New York and Chicago from 1:30 to 2:00 A.M., and both networks have been released during that period. Washington will not start lineup tests until 4:00 A.M., as the B network is released between Denmark and Jacksonville to replace temporarily several sections of open wire with insulated wires, as abnormal flood waters are expected in various lowland sections. Line noise measurements are being made between Memphis and Jackson, Miss., to locate noise due to induction. Cincinnati must await lineup of the section until completion of this special work.

When all of such necessary preventive maintenance work has been completed, each control office measures its section to ascertain that the transmission characteristic and volume are

satisfactory. Similarly, all the spare program transmission circuits in its section are tested by each control office. This completed, New York transmits power at various frequencies over the entire network. The terminals and specified intermediate offices measure the amount of received power. Any adjustments needed are made under the direction of the proper control office.

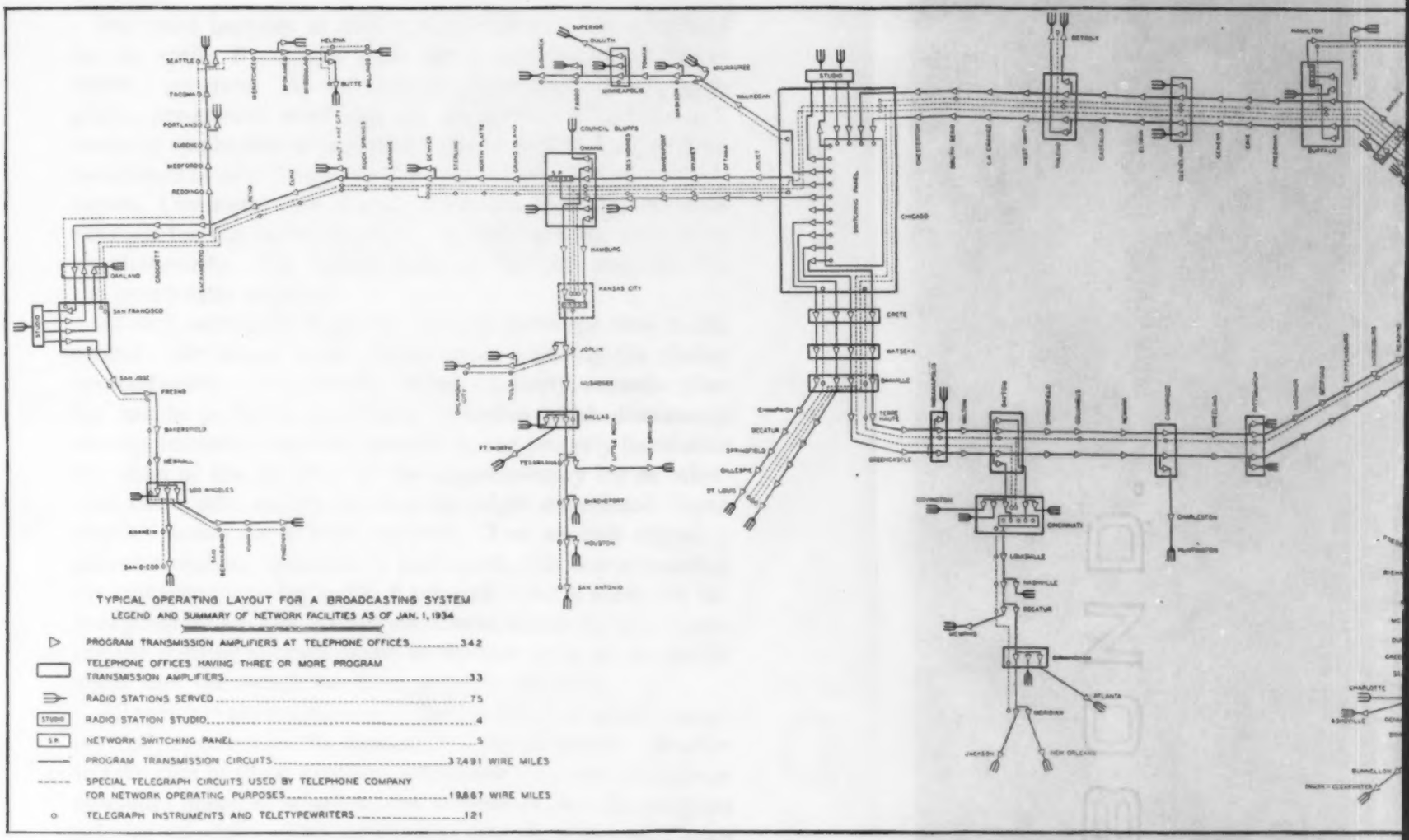
During this midnight-to-morning period, each control office uses the teletypewriter circuit to report the service furnished, troubles experienced, station comments, etc., for the preceding day. The trouble reports are forwarded to the supervisory staff for analysis and record purposes. From the analysis, chronic poor conditions are brought to attention and remedial action initiated.

It is now 6:30 A.M. The New York studios are transmitting test program for the B network. During the next fifteen minutes, by means of the control telegraph wire, New York determines from each office feeding a radio station that satisfactory volume and quality are being received. At 6:45 A.M. the "Morning Exercises" programs begins and it's "all OK" to each of the nine scheduled stations.

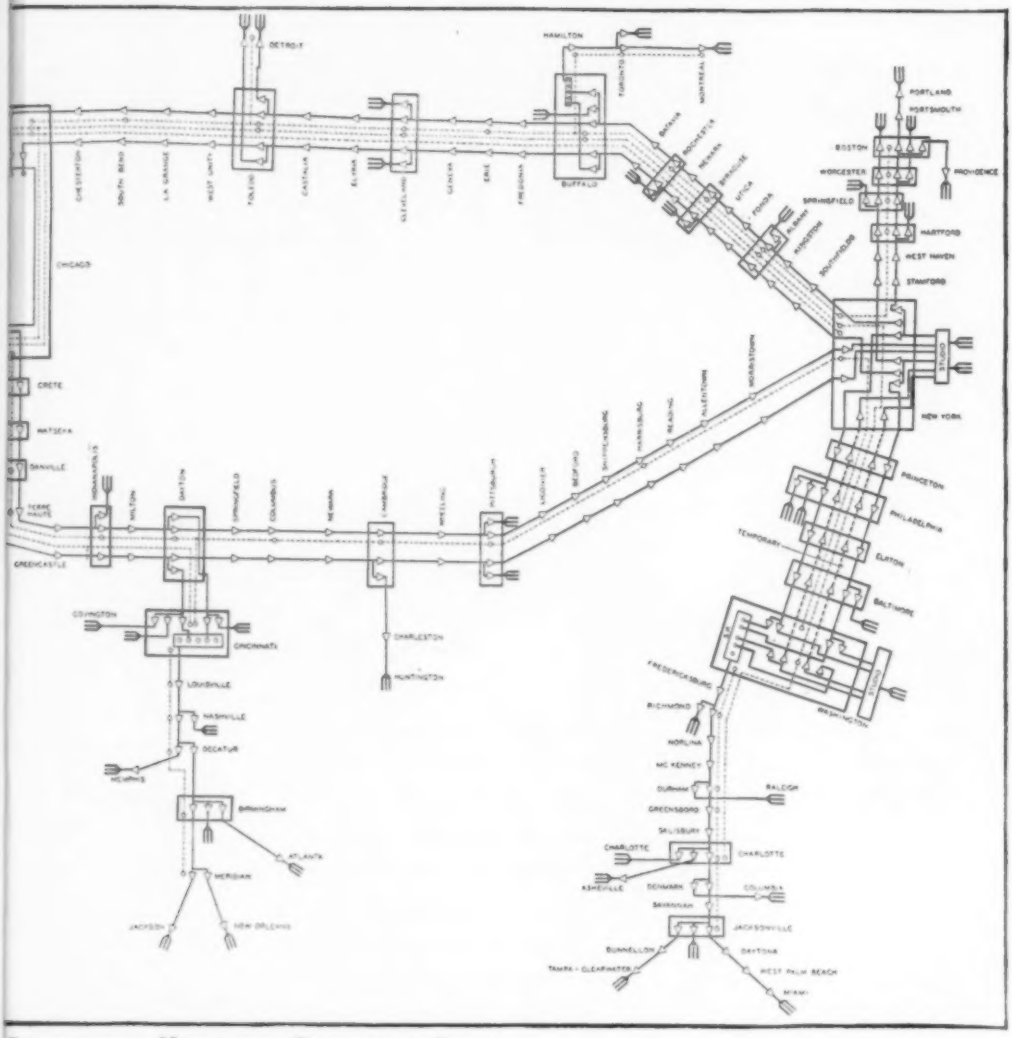
Final arrangements are now made for the start of the day's service at 8 A.M. on the remainder of the B network and the A network. Those sections not receiving the morning overtime service get fifteen minutes test program prior to 8:00 A.M. and each control office determines that "all will be OK" to each radio station in its control section at the start.

Each day the broadcasting company's schedule of operations, showing switching cues and program priority for the following day, is sent to each switching office and from this each office prepares its switching schedule.

At 8:00 A.M. "Morning Meditation" on network A starts the day, while in the same period "Musical Moments" is scheduled for the B network. The northwest, southeast, south central, and southwest sections of the B network start the day



DIAGRAMMATIC REPRESENTATION OF A TYPICAL OPERATING LAYOUT FOR A NATION-WIDE BROADCASTING SYSTEM.



LAYOUT FOR A NATION-WIDE BROADCASTING SYSTEM.

on network A, but since the switching offices involved have had several hours to set this up, these switches required no special attention.

But what happens at 8:30 A.M.? "Bonnie" is scheduled for the entire B network while the A network gets "Organ Music" program. At the close of the 8:00–8:30 A.M. programs, pre-advised word cues are transmitted over both networks by two broadcast announcers from the New York studios. Switchmen at four Telephone Company offices, Chicago, Washington, Cincinnati and Kansas City, are listening on each network for the switching cues. In this case the cues come simultaneously. The coördination of the two programs by the broadcaster is perfect.

As each switchman hears the cues, he notes the time to the second. He listens to the theme music following the closing announcement. It gradually fades. Twenty seconds after the cue, he performs a switching operation which disconnects the supplementary leg from network A, and properly terminates the input of the amplifier on the supplementary leg as otherwise each radio station on that leg might experience "open circuit" noises for a brief interval. Two seconds elapse, a second switching operation is performed, this one connecting the supplementary leg to the B network. All is ready for the next program to start. Each switchman stands by now awaiting the opening announcement of the new program to double check that the switch has been properly executed.

All switches are not so easy. The broadcaster cannot always perfectly synchronize the conclusion of two programs. In order to take care of those instances where one program overruns or concludes ahead of schedule, the switchman uses his program priority schedule. The sequence of operation the switchman will follow is then determined by the switchman, after hearing the first of the unsynchronized cues.

At 9:00 A.M. the supplementary legs are switched to network A at the four offices previously mentioned and also at Omaha

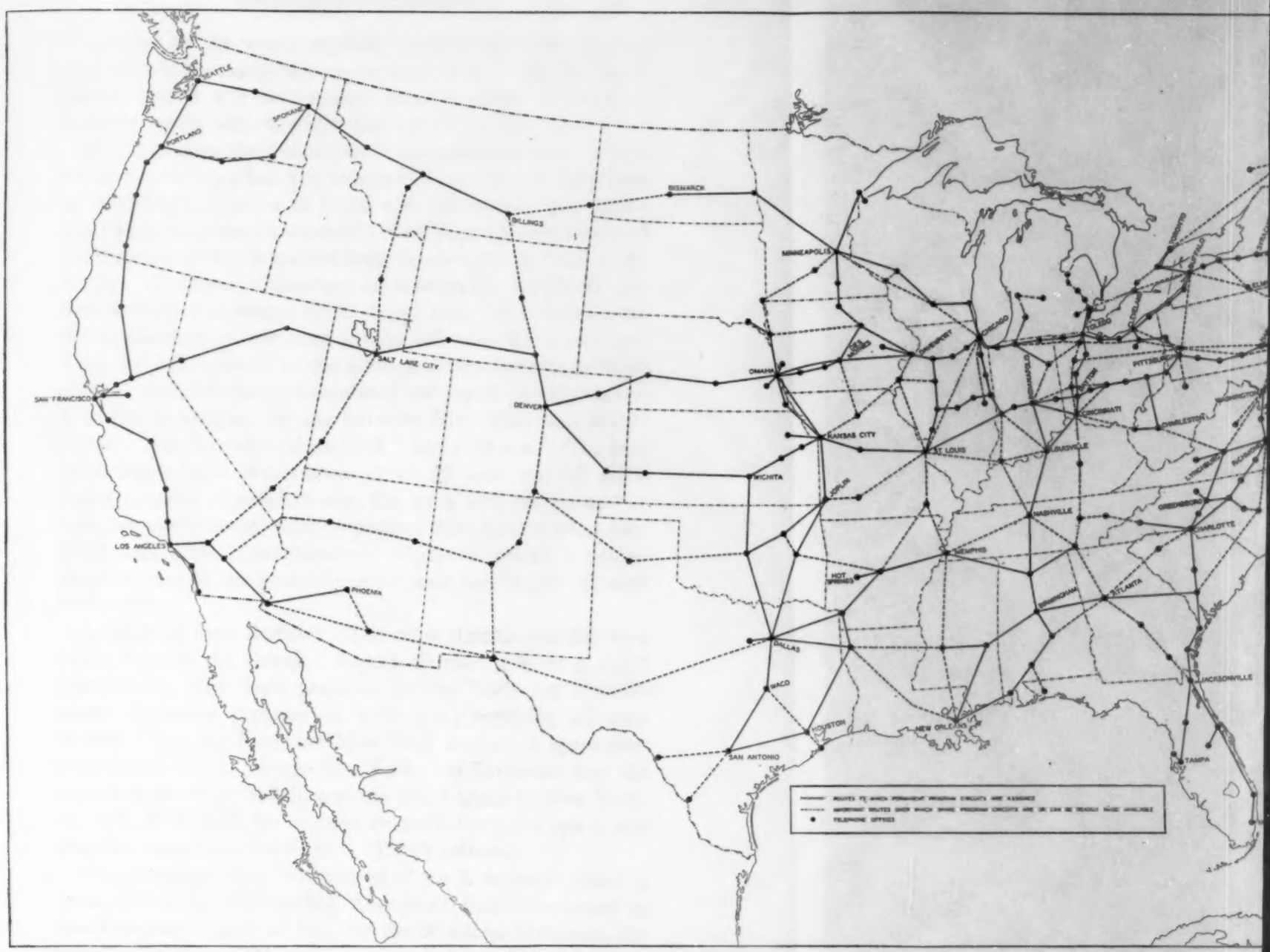
and Buffalo for the "Breakfast Club" program from Chicago for the full hour 9 to 10 A.M. Four fifteen-minute programs are scheduled for the B network during this hour.

The "Housewife" program to the B network at 9:15 A.M. originates at Springfield, Mass., and a special circuit transmitting Springfield to Albany is to be used during this fifteen-minute period. For the past hour, Albany has been preparing for this service, by making a program transmission lineup of the circuit. New York General Control checks Albany as to whether everything is "all set" for the Springfield pick-up and receives an "all OK" report. When the closing cue is transmitted over the B network at 9:15, Albany switches the network to feed from the Springfield circuit.

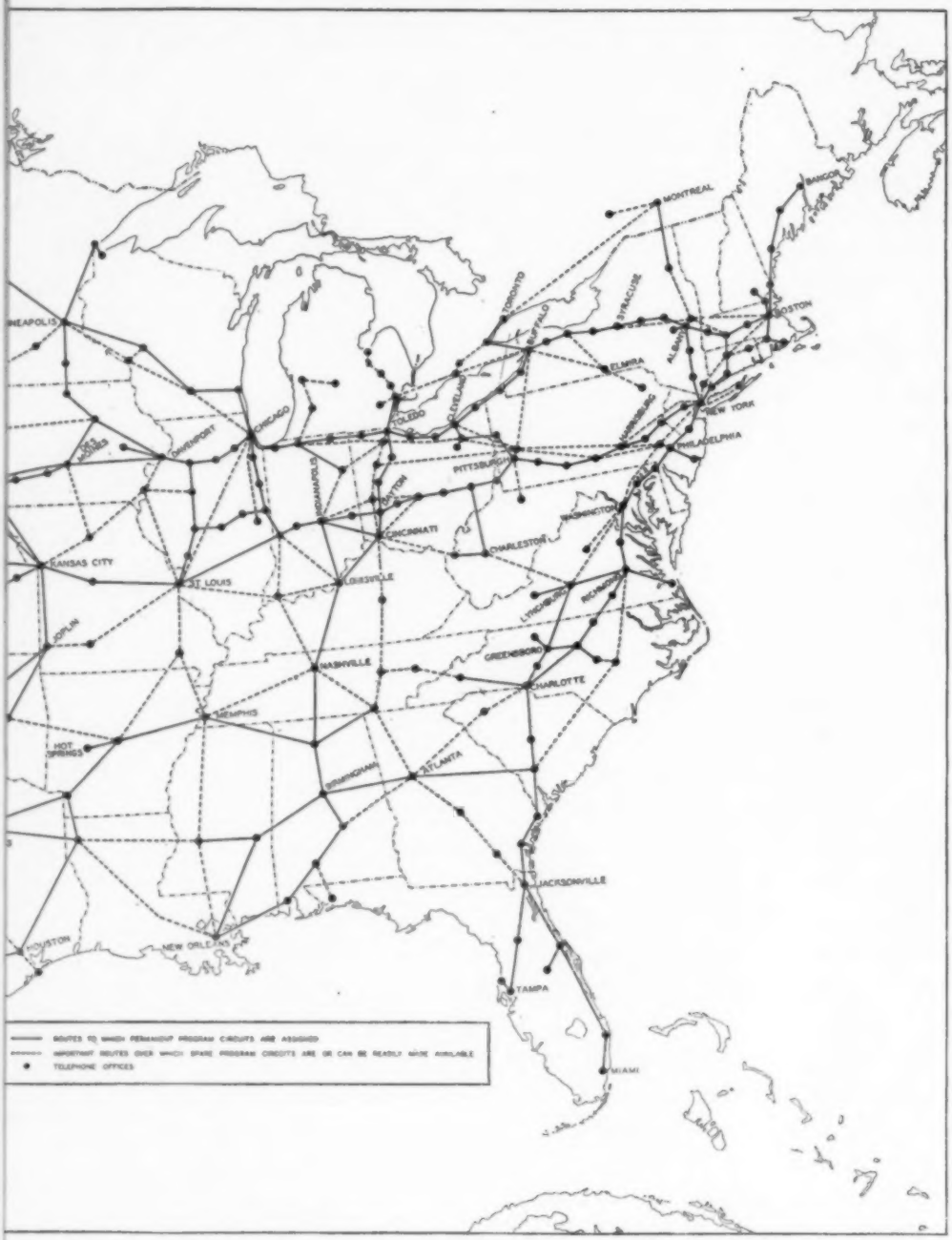
And so it goes each fifteen minutes or half-hour or hour, switching from one network to the other. So far the morning has been uneventful, but at 10:13 A.M. Cleveland flashes New York "Network A just failed." One man at New York, aided by a telegraph wire, starts to locate the trouble while another quickly substitutes a spare program circuit. Service is restored to all points west of Cleveland at 10:15.29 A.M.

Another telegraph flash from Cleveland, "The B network failed at 10:17.30 A.M." The No. 2 spare to Cleveland is connected at New York to the B network transmitting loop and Cleveland is instructed to feed the network west from this spare. All service is restored at 10:18.30 A.M. Buffalo reports the trouble appears to be a cable failure about 30 miles west of Buffalo. Full information is given to the broadcaster with assurance that the Rochester pick-up scheduled for later in the day can be handled.

Chicago, at 11:15 A.M., is advised by Denver that freezing weather prevails on the Central Transcontinental Route around Truckee Pass, Nev.; rain is turning to sleet, ice is forming on the wires, and the wind velocity is increasing. This word is passed to New York and notices are sent to offices along northern and southern transcontinental routes, which routes will not



MAP SHOWING SOME OF THE ROUTES USED FOR PROGRAM TRANSMISSION IN 1934.



OR PROGRAM TRANSMISSION IN 1934.

be affected by the severe weather, to be ready to lineup program circuits for emergency use on short notice. San Francisco advises that it will be prepared to meet either northern or southern routes with facilities into San Francisco.

At 11:18 A.M. the broadcaster's control room says a flash political news story has just broken and service is desired from the Washington studios at 11:30 A.M. It is to be put on the A network from the broadcaster's New York control room and a temporary circuit is needed from Washington to New York. Further, all supplementary legs are now on the B network and were scheduled to remain 11:30–11:45 A.M. This is changed; the supplementary legs must now be fed from the A network. A general call is placed on the teletype circuit for all switching offices. Instructions are formulated and typed simultaneously. A circuit is assigned for use between New York and Washington. The last office signs "OK" at 11:28 A.M. The program starts from Washington at 11:30 A.M. and all radio stations receive it satisfactorily, but by a slim margin and at least ten men in seven widely separated cities have worked with speed and perfect coördination. Figure 3 shows a photograph of one of the general control men taking part in such an operation.

A telegram from Buffalo: "The cable trouble was due to a bullet through the sheath. Expect all pairs OK at 6 P.M." Immediately New York prepares for the Rochester Philharmonic Orchestra program at 3:00 P.M., notifying all concerned: "Use the Rochester-New York section of spare program circuit No. 4 Chicago-New York. At Rochester feed the regular network to Buffalo and the No. 4 spare to New York. At New York feed the regular network from the spare and also the reroute to Cleveland." That's settled.

The next problem is the reversal of the B network, which is normally set up transmitting East–West from Davenport to San Francisco. At 2:00 P.M., for the Woodrow Orchestra, the broadcaster desires West–East transmission. This service is

provided with no change in line and equipment facilities. Equipment and wiring of each intermediate amplifier, Davenport–San Francisco, has been provided so that the connection to the input and output of the amplifier can be quickly reversed between line East and line West by a simple key operation.

A few minutes before the designated time for the reversal, men at each of the thirteen offices monitor the network, awaiting the usual cue. It comes through, reversing keys are operated and dials readjusted to predetermined settings. After this the men stand by several minutes longer to insure that the reversal has been satisfactorily accomplished.

Now a flash from Denver. A pair on the Central Transcontinental line—not the program pair—failed at 2:45 P.M., probably due to sleet. Chicago immediately starts lining up a West Coast program circuit on the Northern Transcontinental route, to be substituted for the program circuits on the Central Line in case the latter go out.

In New York the broadcaster has given corrections to the operation sheet affecting a dozen or so switches in the early evening. These are transmitted to the switching offices involved. New York is also checking various offices for receipt of orders covering a special program from Cincinnati, which will take place 11:30 P.M. to 12 M., requiring a circuit Cincinnati to Dayton, connecting at Dayton to the B network.

Chicago reports OK to San Francisco on the Northern Transcontinental reroute at 4:15 P.M., but as program is still coming through to San Francisco on the central transcontinental route, the northern route has not yet been used.

At 4:30 P.M. the program from the East fails for ten seconds, but an immediate switch at San Francisco to the emergency circuit sustains service with only a few seconds' interruption. Undoubtedly, the bad weather is the cause.

Chicago is advised. Anticipating such a situation, Chicago has prepared a switching schedule for the emergency circuit in accord with the broadcaster's operation sheet, and Pacific Coast

FIGURE 1. VIEW OF A SECTION OF THE TELEPHONE COMPANY'S GENERAL CONTROL OFFICE IN NEW YORK. THE EQUIPMENT SHOWN IN THE PICTURE IS USED SOLELY FOR BROADCASTING NETWORK SERVICE.

FIGURE 2. ONE DAY'S PROGRAM ORDER, 15 FEET LONG, SENT BY TELETYPEWRITER FROM NEW YORK TO ALL TELEPHONE COMPANY OFFICES INVOLVED IN FURNISHING NETWORK SERVICE.

stations will get each program the rest of the day just as if nothing had happened. Omaha must continue switching, too, because the Denver and Salt Lake City stations will still be fed from the regular network.

And so it goes through the remainder of the afternoon and early evening. The General Control Office checks volume readings half-hourly with each control office. Each switching office carries on its switching schedule in accordance with previous instructions. Each office answers calls from the radio station it serves, giving details regarding trouble and coöperating in any way possible. An hour after midnight the day's operation ends and work starts immediately in preparation for the next day with its special problems.

During certain seasons of the year there are days with many times the activity just described. Football games, baseball games, world conferences, political campaigns, storms covering large areas with extensive damage, fill some of them. Other days are occupied by the preparation and operation of large independent temporary networks, which are established at irregular intervals for a one time service of a half hour to an hour's duration.

E. V. WALLACE

Network Broadcasting

III. Telephone Facilities

WHILE the telephone message business is the principal operating undertaking of the American Telephone and Telegraph Company, the furnishing of facilities for program transmission service forms an important part of its activities. To meet the requirements of this service a portion of the physical plant has been designed and especially constructed, or existing plant suitably modified, exclusively for use in program transmission. This plant is set aside for network service twenty-four hours a day every day in the week. It is made up of three main types: equipment, aerial wire and cable plant.

The equipment associated with program transmission service consists of repeaters, power plant, testing apparatus and a proportionate share of the land and buildings required to house the equipment. More than half of the investment in equipment and associated plant is accounted for by the 2,000 telephone repeaters employed in program transmission service. These repeaters have been designed especially to meet the requirements of program transmission service. They are more costly and differ from the repeaters used in telephone message service in several important respects. For example, they will transmit a wider band of frequencies and a wider range of volume. They introduce less distortion through the use of special transformers and contain more refined adjustment features provided by special equalizing equipment which are necessary where programs are to be transmitted over very long distances.

Other special apparatus needed in furnishing this service includes equipment to interconnect sections of the network. For example, at 65 telephone offices throughout the country

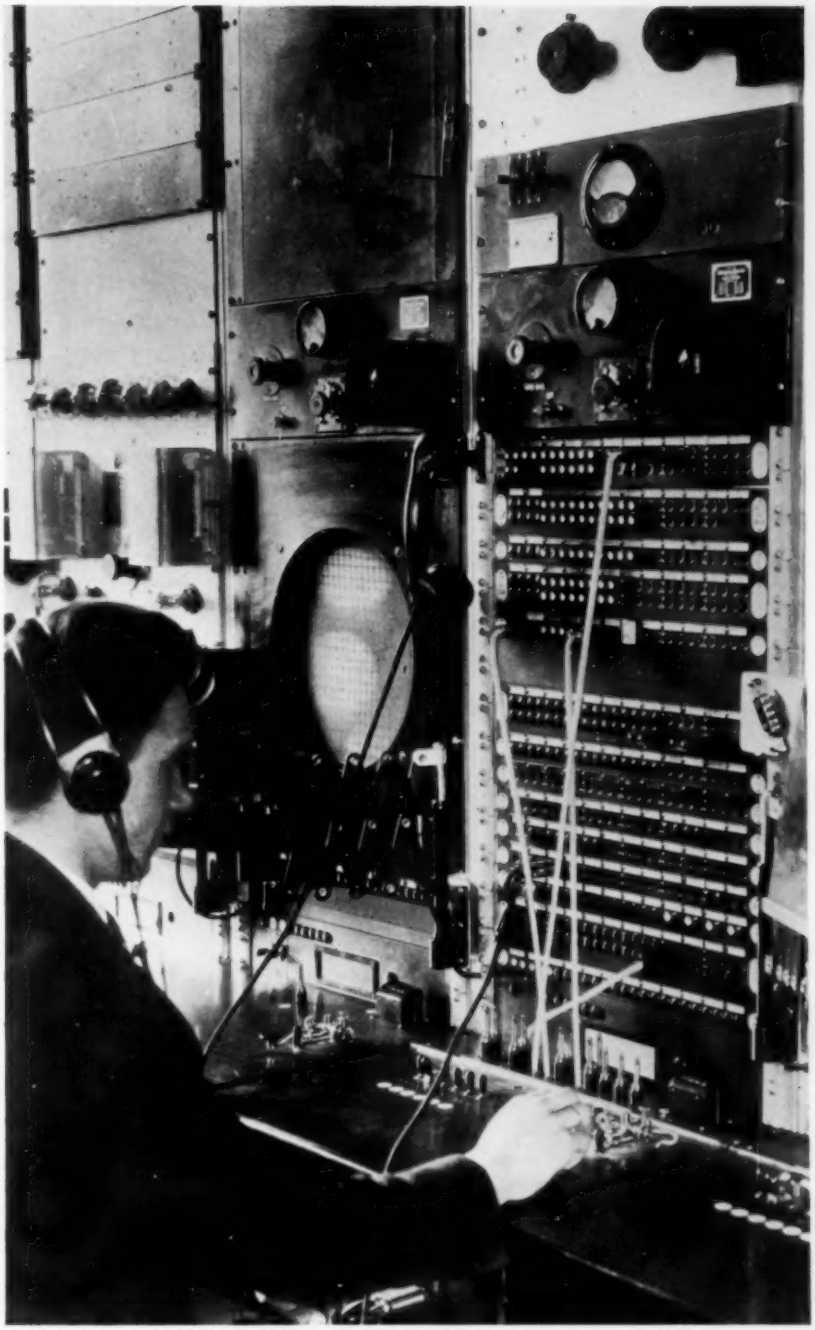


FIGURE 3. ONE OF THE GENERAL CONTROL MEN AT NEW YORK TAKING PART IN A SWITCHING OPERATION WHICH MAY INVOLVE THE COÖRDINATED WORK OF A NUMBER OF OTHER EXPERTS AT WIDELY SCATTERED POINTS.

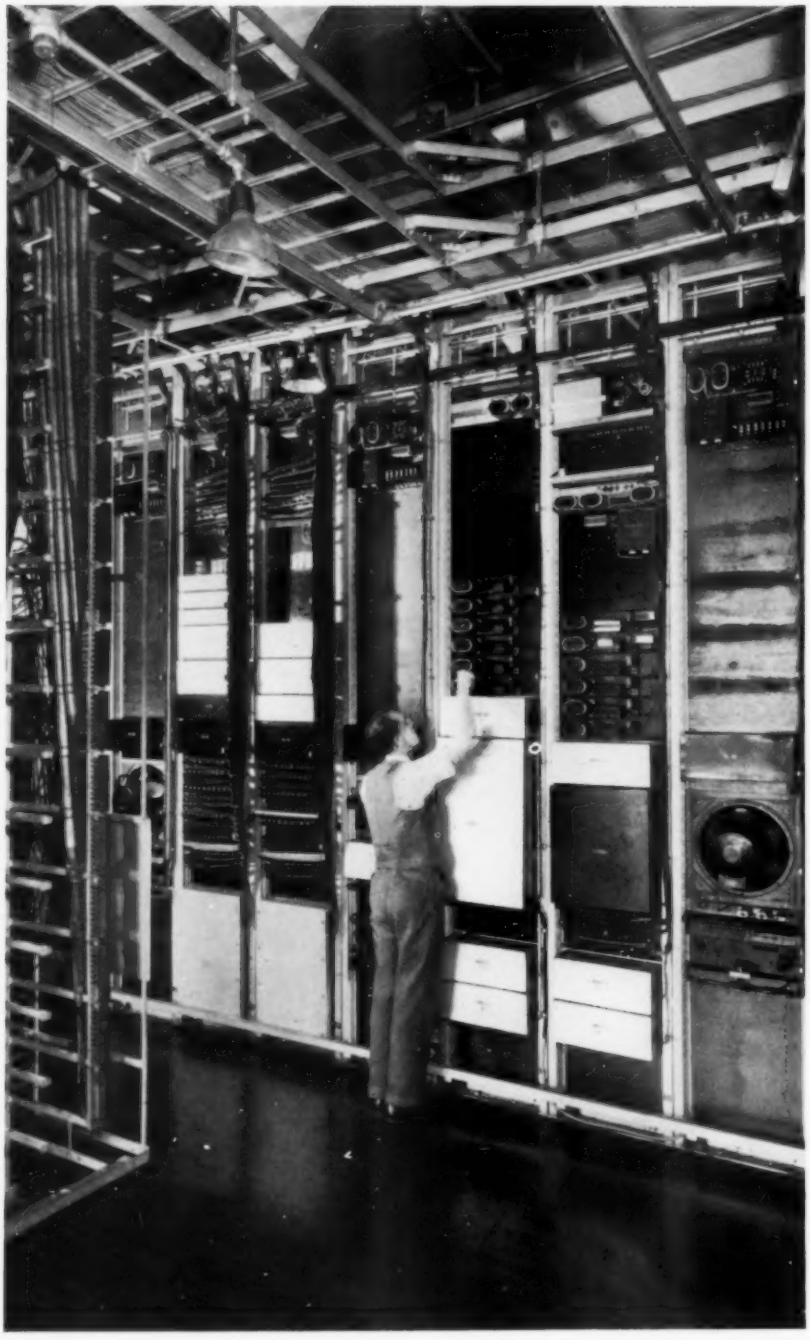


FIGURE 4. VIEW OF EQUIPMENT BEHIND ONE OF THE CONTROL PANELS IN THE GENERAL CONTROL OFFICE AT NEW YORK. NOTE INTERCONNECTION FRAME AT LEFT

such equipment is installed to enable any program passing through that point to be distributed in various directions over separate routes to supply radio stations on such routes. At 262 telephone offices special positions of testboard equipped for testing, adjusting, monitoring and rearranging the broadcasting networks are installed. The number of such positions varies from one panel in the smallest office to about 25 at the larger centers. Switching positions have been installed at certain points to make practically instantaneous rearrangements in the networks at frequent intervals on a pre-selected basis. Figure 5 shows a typical installation of such equipment at a telephone office.

In recent years there has been an increasing trend on the part of the broadcasters toward supplying certain sections of the country with selected types of programs. There is also a growing tendency toward picking up programs from one studio after another at widely distant points. Such procedures involve special arrangements to make possible the reversal of operation of the networks, on the one hand, and, on the other hand, the quick shifting of groups of stations from one network or a section of a network to another at frequent intervals. These new developments in network service require an increasing use of the switching arrangements mentioned above.

The aerial wire plant used for network broadcasting totals about 53,000 miles of wire. It is assigned about as follows: 34,000 miles for full time service; 6,000 miles for recurring service; 8,000 miles for protection and special occasions; 5,000 spare but available for use. If aerial wire were used for regular telephone message purposes a number of additional telephone and telegraph circuits would be secured through the use of so-called carrier systems, phantom circuits, and composite telegraph operation. Due to the exacting requirements of the program service, no composite telegraph operation is practicable and less than ten per cent of the potential phantom telephone circuits can be utilized.

Cable plant devoted to network service provides approximately 59,000 miles of wire equipped for use and about 68,000 miles provided for future use, not fully equipped for service as yet. The wire equipped for use is assigned as follows: 23,600 miles for full time service; 10,000 miles for recurring service; 12,000 miles for protection and special occasions; 13,400 miles spare but available for use.

Practically 90 per cent of the cable wire mileage is made up of 16 gauge cable pairs specially provided for program transmission. Since 1926, these special conductors, usually six pairs in each case, have been placed in nearly all long distance cables. The number of pairs has been determined on the basis of the estimated requirements for broadcasting circuits over a reasonable growth period. It is necessary to place all of them in the cable at the time of installation, as, otherwise, facilities for program transmission would not be available when required. In most cases, three pairs are arranged particularly for transmission in one direction and three for transmission in the opposite direction. These pairs are not arranged for phantom use, as are the other cable circuits, and they are so located in the core of the cable that interference between circuits is reduced to a minimum. The circuits are loaded with special loading coils designed for broadcasting purposes. These coils are placed at 3,000 foot intervals, whereas the usual type of loading coils used on the same cables are placed at intervals of 6,000 feet. While the manufacturing cost of the individual loading coil designed for broadcasting purposes is not greatly different from the cost of coils used for message circuits, the installed cost of the system is considerably greater. Twice the number of coils is used and they are installed in small special cases each containing six coils for equipping the six specially provided cable pairs.

The use of these circuits for message purposes, while physically possible, would not be economical, as the conductors are of larger gauge than would be provided for message circuits,

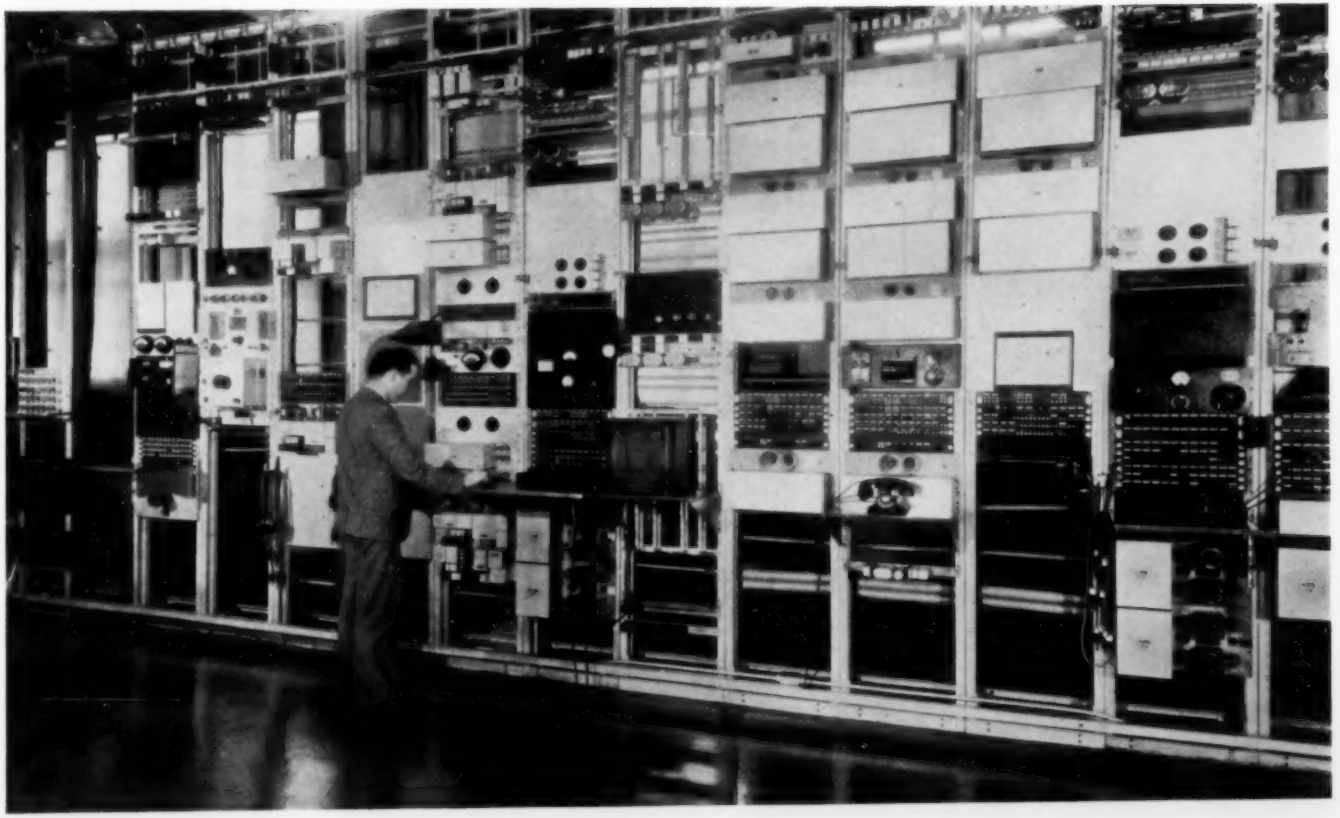


FIGURE 5. VIEW IN ONE OF THE MANY TELEPHONE CONTROL OFFICES CONCERNED WITH NETWORK SERVICE (DES MOINES).

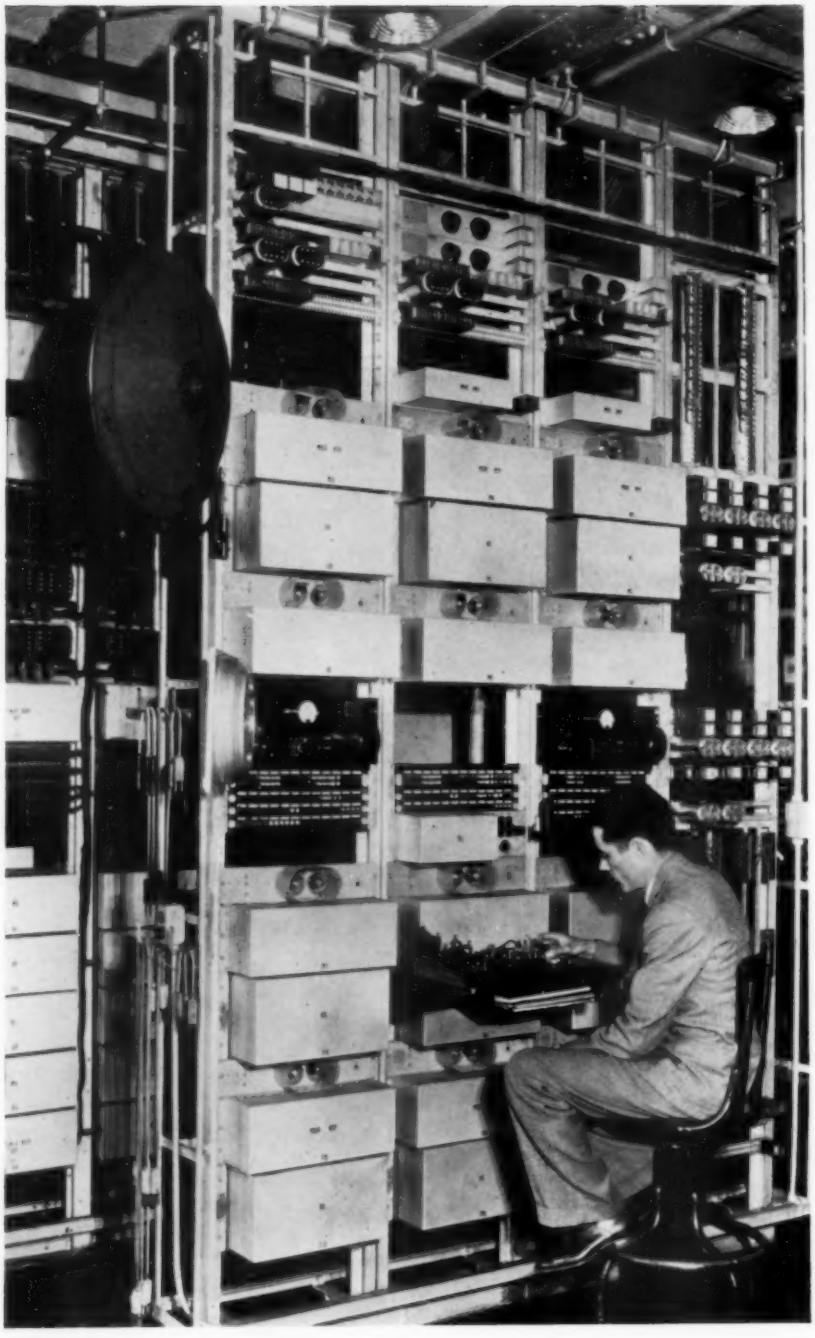


FIGURE 6. IN THE COURSE OF ITS JOURNEY ALONG WIRES, A RADIO PROGRAM PASSES THROUGH NUMEROUS TELEPHONE COMPANY "REPEATER" STATIONS. HERE, AS THE TERM SUGGESTS, THE WEAKENED CURRENTS ARE AMPLIFIED TO THEIR ORIGINAL STRENGTH AND QUALITY, AND ARE SENT ALONG TO THE NEXT SUCH STATION, WHERE THE PROCESS IS REPEATED.

more loading coils with higher overall costs are used, and phantom circuits cannot be obtained. On the whole, the cost of broadcasting circuits, if used for message purposes, would be more than twice as great as circuits which are regularly used.

About 85–90 per cent of the facilities provided by the Bell System for program transmission service is furnished by the Long Lines Department of the American Telephone and Telegraph Company. The figures given below for wire mileages, expenses, revenues and so on are for the Long Lines Department only. For the other Bell System units where facilities are provided exclusively for program transmission service, the relations between investment, expenses and revenues will not differ widely.

At the beginning of 1934 the investment in plant used solely for network service totalled approximately $19,500,000, of which aerial wire plant amounted to $8,400,000, cable plant $7,400,000, and equipment $3,700,000. On a per circuit mile basis the aerial wire investment is $318, the cable $250. These figures are for all circuit facilities set aside for program transmission, whether fully equipped for service or not. If only those circuit facilities which are used on a full time basis are considered, the investment per circuit mile is $500 for aerial wire and $620 for cable.

On the side of expenses, excluding return on investment, the annual charges of the plant devoted to program transmission service, other than operating, amount to approximately $1,800,000. This figure represents charges for depreciation, maintenance, administration, taxes and insurance on outside plant equipment and buildings. The composite percentage of these annual charges is 9 per cent on the total investment. If only that plant in day to day use is considered, the annual charges become 12 per cent on the investment.

The annual expense to the Telephone Company for operating the regular and occasional networks during 1933 was $1,200,000. The total annual cost to the Telephone Company of

furnishing networks for program transmission is therefore approximately $3,000,000 without allowance for return on investment.

The revenue from program transmission service in 1933 applicable to the facilities discussed in the foregoing was approximately $3,500,000. This revenue was derived from the line and station service charges for full time, recurring, and special occasion services. Something more than two-thirds of the revenue was derived from the full time services.

The estimated earnings in 1933 on program transmission service were approximately $500,000, which represents a return on investment of about 2½ per cent. If it were possible to sell sufficient program transmission services at existing rates to occupy to the fullest practicable extent all the facilities which have been provided exclusively for network purposes, it is estimated that the net return to the Telephone Company on its investment would be about 9 per cent.

This investment of the Long Lines Department has been made as a direct response to the demands for better and better programs over the air. This means, as far as the Telephone Company is concerned, that a high type of musical entertainment must be carried for hundreds and some times thousands of miles to all parts of the country, without any appreciable loss in fidelity and tone. (All sudden emergencies must be foreseen and provided against, so that a listener may not be disappointed, when he tunes in to get a particular program at a particular time.)

It may be expected that as time goes on these requirements will become more and more exacting. Due to the complex requirements of program transmission service, it can never become thoroughly standardized. In general, however, its activities can be charted in advance. For the rest, the many sided problems which constantly arise are dealt with immediately and with all the precision that care, experience and foresight can provide.

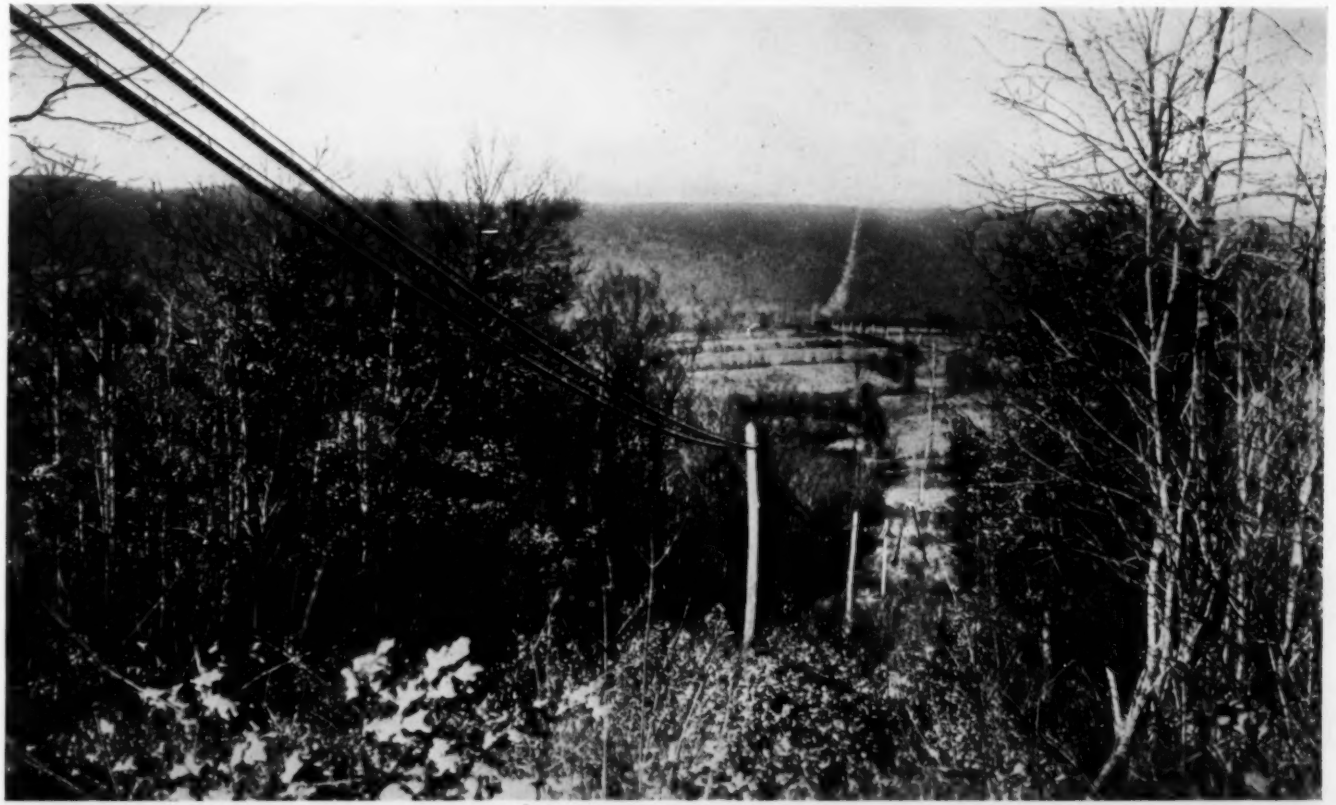


FIGURE 7. RADIO PROGRAMS GENERALLY TRAVEL THROUGH CABLE AS LONG AS THEY ARE EAST OF THE MISSISSIPPI RIVER. THESE "COVERED HIGHWAYS" AFFORD A HIGH DEGREE OF PROTECTION AGAINST WEATHER HAZARDS.

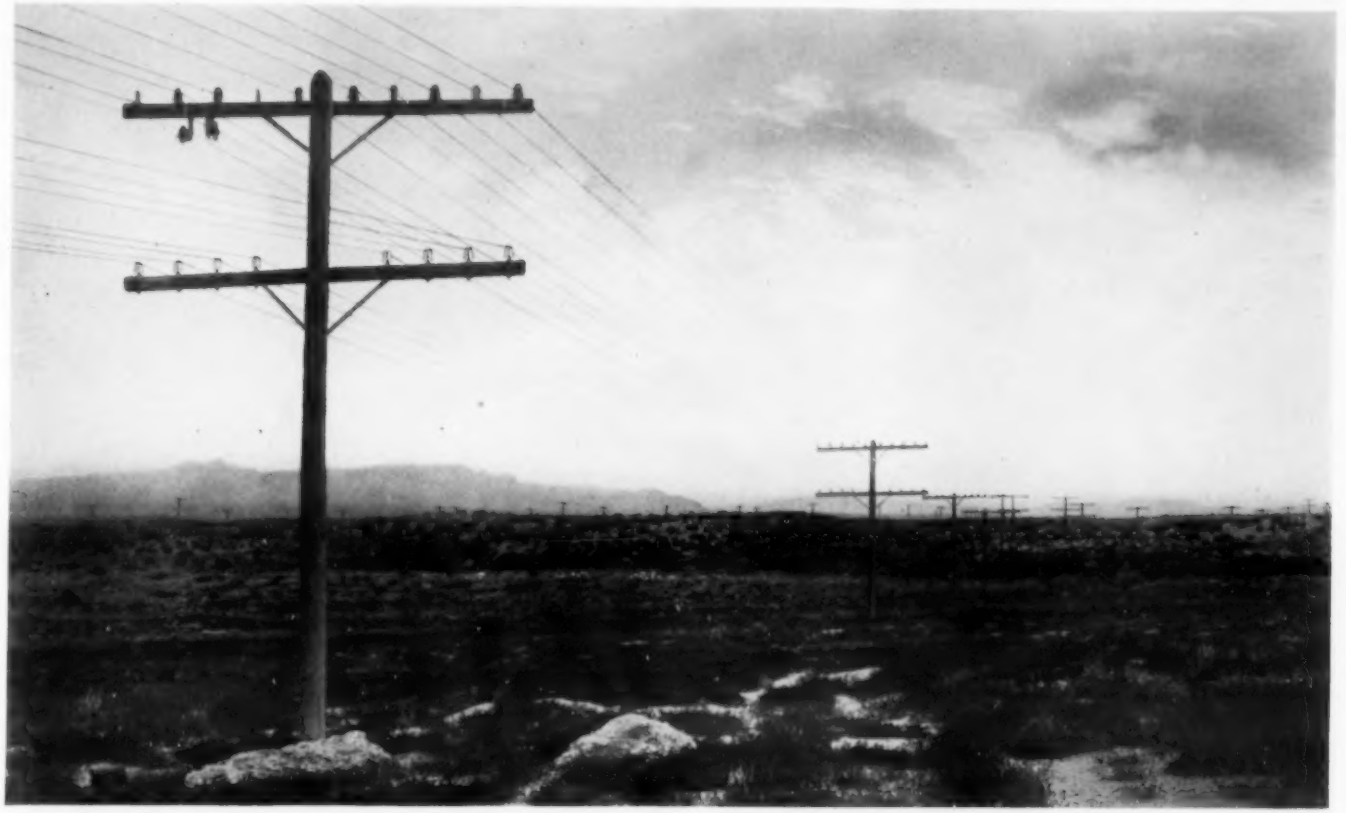


FIGURE 8. BETWEEN OMAHA AND THE WEST COAST, RADIO PROGRAMS PASS, IN THE MAIN, ALONG OPEN WIRE LINES CARRIED ON POLES, RATHER THAN IN CABLE. A TYPICAL SCENE ALONG SUCH A ROUTE IS SHOWN ABOVE.

Program transmission circuits provided today must stand the test of tomorrow's requirements. Every reasonable index as to possible future trends must be considered. Continuous attention must be given to possible future developments and the requirements which may grow out of such developments. This work is carried on by the Telephone Company in conjunction with the broadcasting companies, regulatory bodies concerned with radio broadcasting and other interested parties, to the end that the best and most economical design of circuits can be determined on. Such continuous and coördinated attention to the possibilities of the future insures that methods are fully adequate when new requirements are to be met. Furthermore, the plant, which is continually being added to or rearranged, is designed and installed with due regard to the possibilities of these future requirements.

An illustration of the work which is being done to provide for tomorrow's requirements was the reproduction in Constitution Hall at Washington, on April 27, 1933, of a symphony concert produced in Philadelphia by the Philadelphia Orchestra of more than one hundred instruments. For this demonstration, which was described in the July, 1933, issue of the BELL TELEPHONE QUARTERLY, three specially arranged program transmissions circuits were used. Each was capable of transmitting the entire range of frequencies from 40 to 15,000 cycles per second. Further, the attenuation of all frequencies within this range, which is about three times the width of the bands now used in radio broadcasting, had to be equalized. Otherwise a faithful reproduction of the concert would have been impossible. Likewise, each circuit had to be free from all electrical disturbances in order to prevent any interference with the music.

The demonstration was unique in several important respects. Practically the entire audible range of musical tone was faithfully transmitted. A greater range of volumes than ever before attempted was placed under the control of the Musical Director. Using specially arranged volume controls, he was able to create

tonal effects not possible with the largest orchestras. The sound output from the reproducing loud speakers at times exceeded that which could be produced by a one thousand piece orchestra. At other times the sound was reduced until it was barely audible. By the use of three separate transmission channels covering the left, the right and the center of the orchestra in Philadelphia, the illusion of depth and arrangement of the musical instruments was produced on the empty stage at Washington. The orchestra seemed to be actually present in Washington, although it was 130 miles away in the Academy of Music at Philadelphia.

Circuits of the kind described above, while not now available for use on a country-wide basis, can be made available should commercial requirements develop.

The process of looking ahead to tomorrow's requirements is continuing. The engineers and the operating men connected with program transmission service have endeavored to be at all times in advance of developments in broadcasting. The wire networks and the operating personnel have been ready to meet new conditions as they have arisen.

The ultimate goal, of course, is reproduction of music and speech in the listener's home—wherever located—so nearly equivalent to the actual program that there will be no perceptible difference. Recognizing its responsibilities in providing its share of this service, the Telephone Company is planning its plant and operating procedures with this objective in view.

G. S. Bibbins

Teamwork at Anderson, Indiana

A CENTRAL office serving 5,500 telephones wiped out by fire and completely replaced by a new central office in a new location in less than two weeks: that, in brief, is the story of what happened recently at Anderson, Indiana.

Anderson is typical of hundreds of other towns in the United States: population something less than 40,000; factories for the making of electrical goods, tools, automobile accessories and other products; a trading center that supplies the needs of the surrounding agricultural region; schools, churches, hospitals and homes; people going about their business and professional lives and their social activities very much as Americans do everywhere, telephone service, up to the early morning of Monday, January 29, 1934, being taken as a matter of course.

A few minutes after one o'clock on that morning in January, two night operators were at work in the Anderson exchange: quite enough to handle the small amount of traffic on the switchboard as all but a few of the people of the city slept. Below, in the lobby, the night elevator man sat reading a book. As he glanced up, he became aware of a curious red glare in the windows of a drug store across the street. He stepped out to investigate, found that the light was reflected from a fire that had broken out in a department store on the first floor of the building from which he had just come. The blaze was rapidly gaining headway.

By daybreak, the local and long distance switchboards were merely masses of twisted and blackened metal, the plant and traffic records had been reduced to ashes. All of the 5,500 telephones had been cut off from communication with each other and with the outside world. A city's telephone service, which had taken years to build, had been rendered useless in a night.

A gigantic task, considering the time element, now lay before the telephone company—an emergency that would test the organization's ability to mobilize materials and men to tackle a difficult problem and solve it, swiftly and surely.

On Sunday, February 11, at 11:30 P.M., a few hours less than fourteen days after the fire had been discovered, the job was finished and service was permanently re-established. A new exchange, in another building, had been installed and all telephones were receiving service just as if there had been no fire. These were the results of two weeks of intensive activity on the part of the organizations of the Indiana Bell Telephone Company and the Western Electric Company, aided by the facilities of the Bell System as a whole. To these results, important contributions were made by material suppliers outside the Bell System, transportation and express companies, newspapers, printers, hotels, and the city officials and people of Anderson, all of whom gave splendid co-operation during the entire period of the work.

Emergency Service

More urgently important, from the standpoint of time, than the problem of permanently restoring service was that of providing emergency equipment to meet the most pressing needs of the city while the wrecked exchange was being replaced. These two phases of the work went on simultaneously, but the provision of temporary equipment will be discussed first and then consideration will be given to some of the outstanding phases of the work of permanent restoration.

At the height of the fire, some three hours after its discovery, it became apparent that the loss of the central office would be complete. Steps were taken immediately to establish emergency service, and valiant work was done by the operators in this connection, as was also the case when the fire started. Telephones were connected to toll lines at the nearest practicable point in the outskirts of the city where these

toll circuits were easily accessible. This arrangement connected Anderson with the outside world and the service it provided was available in the early hours of the morning of the fire.

At the same time, work was begun on the installation of small sections of switchboards in the telephone company's business office, a block away, and by afternoon long distance circuits to Indianapolis and Muncie, Ind., were available for those who wished to come to the office to make toll calls. Further long distance facilities were rapidly added to cover other routes.

Emergency service was also established on a magneto switchboard for a limited number of local telephones serving points which, in the public interest, particularly required service during the crisis. These included the police department, fire stations, sheriff's office, hospitals and newspapers, which were equipped with magneto telephones so that they might "carry on" until service had been permanently restored. As rapidly as possible this type of service was extended to other strategic points in the city.

Many private branch exchanges, which had normally been supplied with electrical current from the storage battery plant at the central office, were quickly equipped with local batteries so that, even though outside calls could not be made, intercommunicating service on the premises of the subscribers could be given.

Problems Involved

Something of the problems involved in the work of providing temporary service and in that of permanent restoration may be seen by reference to the accompanying sketch (Figure 1) showing the location of the former central office, in the Citizens Bank Building, and that of the new central office, in the Paramount Theater Building, together with the cable ducts leading to these two buildings. The business office on Twelfth Street is also shown. In the alley between the bank building and the theater building is a manhole through which all the

underground cables passed in reaching the former central office. A temporary cable was run from this manhole, through the basement of the theater building, to the business office and there connected to the temporary switchboards. Circuits through the temporary cable were then extended by selecting pairs in the existing underground cable, which would lead to

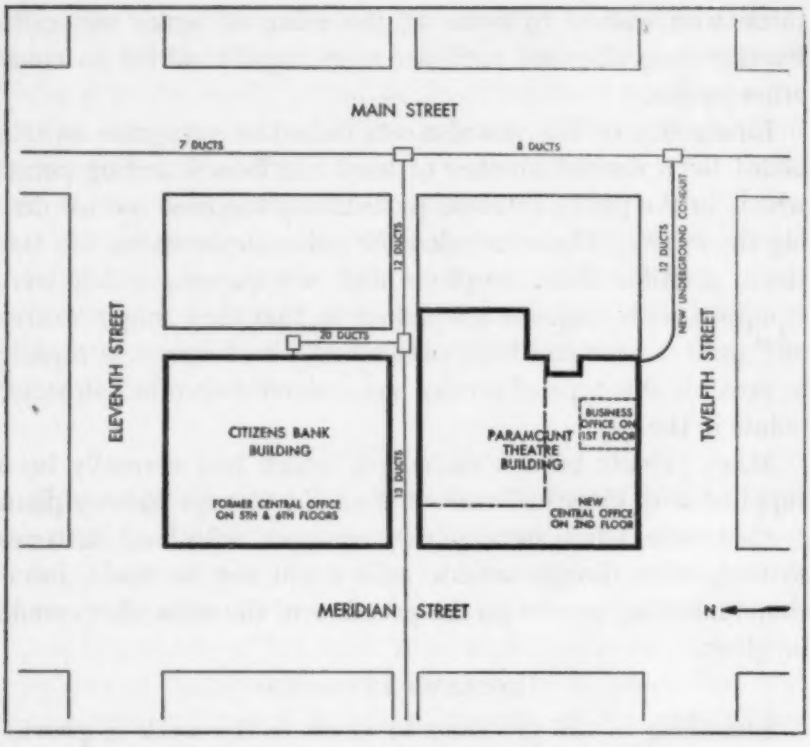


FIGURE 1. THE LOCATION OF THE OLD AND NEW CENTRAL OFFICES.

the desired points at which temporary service was to be provided. Although this arrangement was convenient, the work was made unusually difficult by the zero weather conditions existing at the time.

Turning now to the problem of establishing permanent service, it may be well to glance again at the sketch showing build-

FIGURE 2. THE LOCAL SWITCHBOARD IN ANDERSON AS IT WAS BEFORE THE FIRE.

FIGURE 3. WHAT WAS LEFT OF THE LOCAL SWITCHBOARD IN ANDERSON ON THE MORNING OF JANUARY 29.

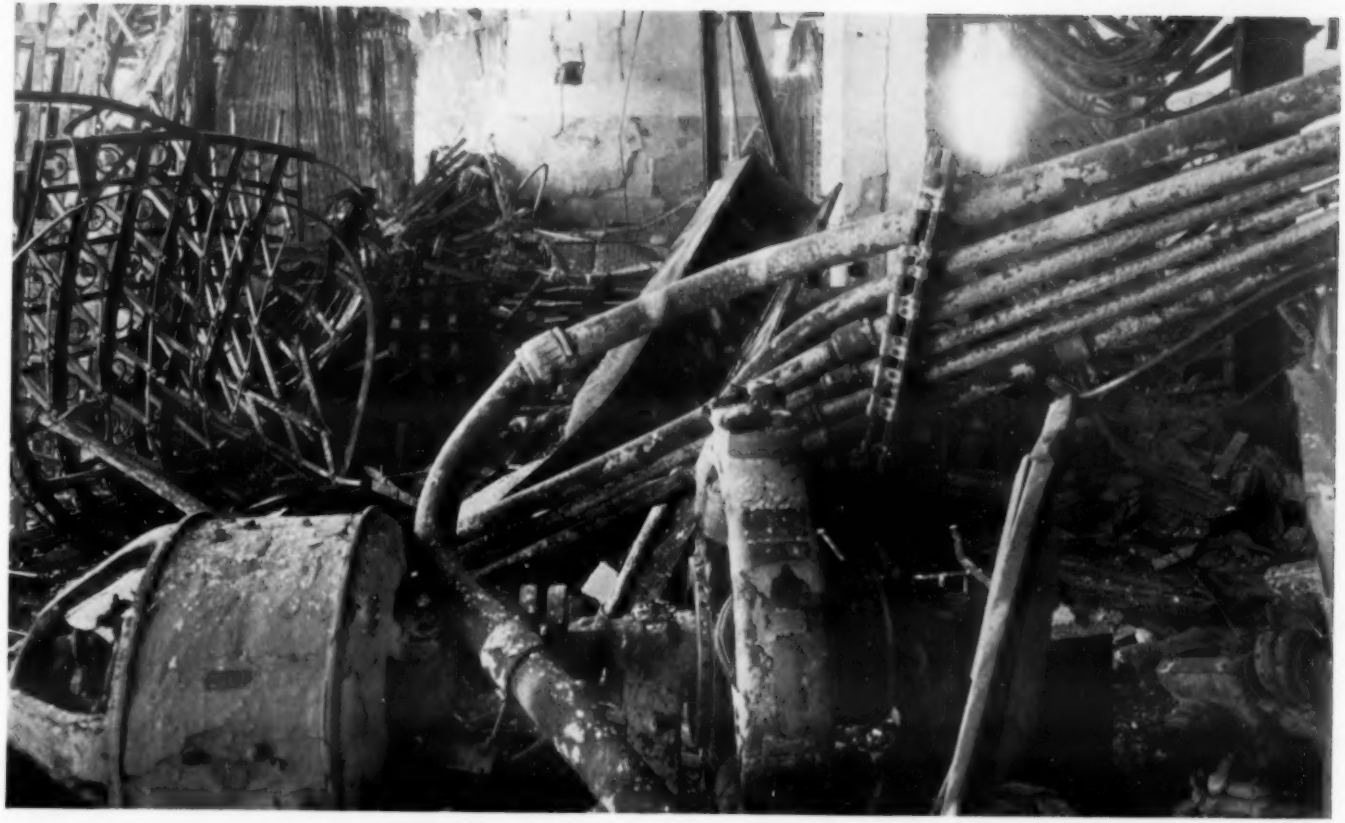


FIGURE 4. THE TERMINAL ROOM OF THE ANDERSON, IND., EXCHANGE AFTER THE FIRE.

ing locations (Figure 1). The Citizens Bank Building, in which the telephone exchange was located, was a six-story structure of steel, brick and tile, with concrete floor slabs. The fire was reported to have started on the first floor, traveling upward to the roof. It was confined to the ground floor and to the south and east portions of the upper floors. The combustible portions of the building, consisting of window frames and sash, doors, interior trim and floor coverings, together with the contents of the south and east portions of the building, were totally destroyed. Figures 2 and 3, showing the former local switchboard before and after the fire, give some idea of the destruction resulting from the blaze. Two smaller buildings on the east side of the bank building were burned. The Paramount Theater Building, in which the telephone business office is located, was unharmed.

Preliminary Plans

Plant men at the scene of the fire had no sooner reported to headquarters of the Indiana Bell Telephone Company at Indianapolis that the exchange would be completely destroyed, than preliminary plans for a new one were under way. A small group of equipment and traffic engineers was assembled and data from the Anderson office, on file at headquarters, were examined. This study indicated that a Western Electric Company No. 11 Type switchboard should be secured if available. Reversing the usual procedure followed in normal installations, the engineers decided to order the switchboard, main distributing frame and miscellaneous equipment at once and find a place in which to install this apparatus while it was en route. The detailed engineering would be done as soon as a suitable location was obtained and dimensions could be determined.

Negotiations were immediately undertaken for the leasing of suitable space, the possibilities of several locations being developed simultaneously. The Paramount Theater Build-

ing was selected as the most desirable, the building being well located close to the site of the former exchange and consequently to the center of the established underground cable systems. It offered about 7,000 feet of floor space on the second floor, without existing partitions and with adequate ceiling height. The building is of reinforced concrete construction, with brick exterior walls and has metal windows with wired glass in the exposed areas.

While the negotiations for the new building space were being carried on, a complete layout of the theater building space, drawn to scale, was shipped to the Kearny, New Jersey, works of the Western Electric Company, by air mail. Before work on certain portions of the equipment could be started, specific dimensions of the room in which it was to be installed were required. These plans were accordingly sent, with instructions to begin work immediately on advice that the lease for the new exchange space had been executed.

Service of Supply

Few more convincing proofs of the efficiency of the Bell System's "service of supply" could be found than that provided by even a cursory examination of the problem which confronted various branches of the Western Electric Company as a result of the fire, and of the manner in which this problem was handled.

A major part of the equipment supplied came from the Kearny works of the Western Electric Company but, before the job was done, sources of supply located in fourteen different cities had contributed to the installation of the new office. These included the Kearny works and those of the Western Electric Company at Hawthorne, Illinois, and Point Breeze, near Baltimore, Maryland, and its Indianapolis distributing house. But they also included outside suppliers located at such widely scattered points as Fort Wayne, Indiana; Newark and Bloomfield, New Jersey; Lynn and Pittsfield, Massachu-

setts; Philadelphia, Pennsylvania; Detroit, Michigan; and New York City, Mount Vernon, and Schenectady, New York.

At one point or another, every operating department of the Western Electric Company participated in carrying some part of the work through to completion. The crews most vitally concerned lived with the job until they saw it finished.

To the equipment engineers of the Kearny plant fell the exacting task of engineering the new switchboard, issuing specifications to the plant and to the installers in the field, ordering the material needed from outside suppliers and so arranging the whole job, from start to finish, that the installers on the scene would receive the apparatus as nearly as possible in the sequence in which they needed it.

Ready for Shipment

Under the Western Electric Company's present set-up, the major units of equipment for an office of the type which was to be installed in this case are carried in stock and are ready for immediate shipment. The problem, therefore, of the equipment engineers was to adapt the stock equipment on hand to the conditions peculiar to Anderson. The fact that such a stock was on hand made it possible to ship the material so that it was available as quickly as it could be used by the installation force.

Formerly a fire emergency stock was carried, but this practice was discontinued several years ago, when the plan of carrying switchboard sections and other units in stock was inaugurated. The new plan proved its adequacy in this emergency, not only by making prompt shipment possible but by providing equipment that was better suited to the needs of the particular location in which it was to be used than would have been possible with the fire emergency stock.

Nevertheless, an enormous amount of work had to be done, and done at top speed, in order that material might be shipped at the earliest possible moment. No switchboard multiple

had been manufactured at Kearny for some time and only one operator skilled in this work was on duty at the plant when the order was received. By telephone, telegram and automobile, a crew of forty-nine men was assembled, including nine central office installers from the New Jersey area. The factory cabling job involved 42,000 jacks and lamp sockets. Connecting each of these to the cable required twenty separate operations such as cutting, waxing, skinning, forming, sewing, fanning, soldering and inspecting—a total of 840,000 individual operations. Various wired units which are ordinarily made on manufacturing schedules of from six to ten weeks were turned out in twenty-four to forty-eight hours.

High-Speed Manufacturing

As has been said, news of the fire reached Kearny on Monday morning, the day of the fire. On Tuesday, the first consignment, including standard units of the switchboard, bulk cable and much of the material available in the Merchandise Department was shipped. This shipment weighed 25,000 pounds. By noon on Wednesday, the floor plans of the new exchange had reached Kearny, word had been received by telephone that the lease had been executed and the job of engineering and producing the multiple began. The multiple was manufactured in layers and shipped in sequence, so that the installers could lay it from the bottom up. In other words, as soon as the installation crew was ready to work with a specific piece of equipment, this equipment was on hand, ready for use.

Almost as noteworthy as the work done at the Kearny works was that of the Point Breeze plant in handling an order for a length of quadded cable required to extend the long distance circuits into the new office. The order for this cable, which included 359 pairs of wires, was received on the morning of the Thursday following the fire. Machinery was put in motion at once and, due to the advanced methods of manu-

facture developed by the Western Electric Company, the cable was completed by Saturday forenoon. A special car was provided and the cable left Baltimore Saturday night. It reached Anderson on Sunday evening, and within an hour after its arrival it had been pulled into the underground ducts leading to the new central office.

The problem of arranging transportation for all this material was, in itself, one of major importance. This phase of the job was handled by the Traffic Department of the Western Electric Company. Six shipments were made by air mail. These consisted mainly of drawings and specifications for the use of the installers. One of the last consignments of apparatus, however, was carried by air mail and arrived in time to make the cut-over possible as scheduled. With this exception, all material and equipment was shipped by express, in several cases in special cars which had to be arranged for in advance.

Speeding Up Shipments

Ten hours' traveling time was saved on all shipments out of the Kearny plant by having them trucked to New York City, from which there are a number of passenger trains a day that connect directly with Anderson. For eleven days, these trains carried in regular or special express cars Western Electric material destined to take its place in the new telephone exchange. In all, over 105,000 pounds of apparatus and supplies were shipped from various points, of which nearly 80,000 pounds came from the Kearny plant. The Hawthorne plant shipped over 10,000 pounds, including cable and equipment and a large proportion of the tools and testing apparatus used on the job.

The material in Hawthorne's shipments was so vitally important that upon its prompt arrival depended the uninterrupted progress of the work at Anderson. Hawthorne met every demand and filled requests as rapidly as they came. Virtually every order was shipped the day it was placed and arrived at Anderson the next day.

Many instances could be cited. Shortly after closing time on February 2, an order was received for forty-two test sets required the following day. A crew worked late into the night calibrating and checking and before morning of the next day, the sets were packed and on their way.

The most urgently needed testing equipment was loaded into the car of a Hawthorne official who drove it to Anderson and stayed on the job acting as contact man between the factory and the installation force.

Mobilizing Man-Power

So much for the Western Electric Company's really remarkable work in mobilizing materials for this important emergency job. What it did in the mobilization of man-power was hardly less noteworthy. By telephone and telegraph the summons for installers went out to surrounding areas. Soon these expert craftsmen began to arrive: thirty-five from the Chicago area, fifteen from the Detroit area, twenty-nine from the Cleveland area. In addition, twenty-one ex-employees were recalled from the nearest points. When the installation job was in full swing, 100 installers were on duty, working in three eight-hour shifts. Day and night, without let-up, they kept at it, working as closely together as was possible without interfering with each other, as is shown in Figure 5.

While this "service of supply" was functioning as just described, the outside plant force of the Indiana Bell Telephone Company was also doing a most noteworthy piece of work. As has been said, these men appeared on the scene while the fire was still under way and took the initial steps toward the restoration of service. They also had heavy responsibilities arising out of the provision of temporary service during the emergency. But the problems involved in preparing, in advance, to connect the new exchange with the existing cable system are of particular interest. What these problems were, and how they had to be solved, will become somewhat more

FIGURE 5. SOME OF THE 100 WESTERN ELECTRIC INSTALLERS WORKING ON THE HORIZONTAL SIDE OF THE INTERMEDIATE DISTRIBUTING FRAME AND RELAY RACKS.

FIGURE 6. PART OF THE CROWD THAT ATTENDED THE "OPEN HOUSE" HELD ON THE EVENING OF FEBRUARY 13 ONE DAY AFTER THE SERVICE WAS RE-ESTABLISHED.

clear to the reader who is not familiar with the details of the telephone business, if a brief description is here given of the telephone cable plant in a city of the size of Anderson.

Plant Records Destroyed

One of the dominating features of a central office is the main distributing frame. It is the meeting point for the wires from the outside plant, which radiate to the homes and offices of the subscribers, with the wires leading to the switchboard. On one side of the main frame, the wires leading to the switchboard are permanently soldered to numbered terminals corresponding to the numbers of the switchboard, which are the numbers assigned to the subscribers and published in the telephone directory. On the other side of the main frame, the pairs of wires which enter the office in cables, stretching out to all points in the city, are soldered to terminals bearing permanent numbers, called the cable-pair numbers. With this arrangement, any cable pair may be connected to any switchboard number by placing cross-connecting wires through the main frame.

Each cable pair extends from the main frame out through the underground and aerial cables, and appears again at a cable terminal, somewhere in the city, bearing its proper pair number. These cable terminals may be located in the larger buildings, where there are a relatively large number of telephones to be connected with the system, or on poles in the streets, alleys or other points throughout the city. In any case, the cable terminal is the point at which the line running to the subscriber's telephone is connected to the cable system.

This description will perhaps give point to the statement, earlier in this article, to the effect that in the Anderson fire all the telephone plant records were completely destroyed. In every telephone area, the whole system of cable distribution is carefully planned and a detailed record kept of the location of every outlying cable terminal in the city and the individual numbers of the pairs which appear in that terminal. This

record reveals, also, the pairs which are idle and those which are in service and, in the latter case, the switchboard number to which it is cross-connected on the main distributing frame.

These records had been destroyed. Not only the local and toll switchboards, but the main distributing frame and the cables which entered the former telephone office lay in a tangled mass. The wires of these cables were connected at their distant ends to cable terminals somewhere in the city—nobody knew where. The identity of each pair had to be discovered. This was done by testing through to the outlying cable terminals, where the number of each pair was available. This work, known as "tagging," was carried on by crews of cable splicers and their helpers.

New Cables Laid

Meanwhile, it was necessary to link the existing cables, which had formerly led to the old office, with the new location. As soon as the location of the new office had been determined, excavation work was started on Twelfth Street for the subway, or system of underground ducts through which the cables were to be run, that would intercept the Main Street route and extend the underground system to the new office. The work of excavating and constructing the extension and replacing the paving was quickly accomplished. "Quick-setting" cement was used and artificial heat was applied to prevent its freezing. Five cables, each containing 1,800 pairs of 26-gauge wire, for use in this extension, had to be ordered and delivered and were immediately pulled through the new subway and terminated on the new main frame.

While this was being done, the work of "tagging" went on. The new cables were spliced to the existing ones. When splices were completed, each pair formed an unbroken metallic circuit from the outlying cable terminal to the main distributing frame and bore the same number at either end. But another job, not less important, had still to be done. Until the

telephone numbers of the subscribers, who were connected at the distant ends of the cable pairs, were ascertained, they could not be cross-connected to their proper numbers on the switchboard. One method of obtaining this information would have been to wait until the cables had all been connected through to the main frame and then to ring out from the central office, securing the telephone number from the subscriber who answered, and making the necessary cross-connection records from the data thus obtained. This would not have been a difficult job, but it could not have been undertaken until the cable work had been completed. Time was precious and it of course was necessary, wherever possible, to overlap operations in order to speed up the completion of the job. To accomplish this result, a field canvass was made, the record of telephone numbers with their related cable pair-numbers was reconstructed, and cross-connection wires were placed on the main frame while the cable work was still in progress.

Co-ordinated Activities

Other activities had to be co-ordinated with those already described and with each other—all of them concerned in one way or another with the job of restoring service and being certain that, when restored, service would be as good as it was possible to make it. The new space was arranged to meet the requirements of a telephone office; an underground entrance was constructed for the cables, with ducts leading to the second floor; reinforcement for floors was provided at points where it was made necessary by the installation of the heavier parts of the equipment; a rest room was provided for the operating force and fully equipped; plumbing was installed and the electric wiring rearranged to meet the special requirements of the operating room.

A new telephone directory was necessary, due to the fact that the switchboard multiple numbers would not run as high, numerically, on the new switchboard as they had on that which

it replaced. Some of the subscribers' numbers, accordingly, had to be changed. The new directory was printed and distributed to subscribers before the new exchange was cut over for service.

Information bureau records, long distance rate and routing instructions and other local traffic records—all of them vitally essential to efficient service—were reproduced. The operating force was instructed in unfamiliar features of the new switchboard. When 11:30 arrived on the night of February 11, everything was ready and the exchange was placed in service.

On February 13, the people of Anderson thronged the new central office building, not merely to see the results of these fourteen days of labor, but to express their appreciation for the manner in which this work had been done. City officials and the business and professional men of Anderson were enthusiastic in their praise of the telephone company for its record-breaking job of restoration. A number of business firms inserted paid advertisements announcing their new telephone numbers and expressing their admiration of the men who had brought the city, from a communication standpoint, back to normal.

The press was equally outspoken in paying tribute to the people of the telephone company. The *Anderson Herald,* in an editorial in its issue of February 13, said, in part:

"To the telephone officials we all owe a word of thankfulness for the remarkable speed shown in re-installing a more modern system over the wreck of the old. Telephone officials inform us that a world record has been established in the installation of the new Anderson exchange in the two weeks since the fire completely destroyed the old."

In similar vein, the *Anderson Bulletin* said, on February 9, while the work was still in progress:

"The telephone company is to be congratulated on its speedy action in restoring service in a comparatively short time. . . . Although lack of telephone service caused some individual inconvenience and proved a handicap to thousands of residents of the community, the public in general

took the situation philosophically, and as a result there has been little real difficulty."

This understanding attitude on the part of the public, and its active co-operation with the telephone company, were important factors in making the record-breaking reconstruction job a possibility.

VANCE OATHOUT

Editor's Note:

A fire on Saturday, March 10, which destroyed the department store of Loveman, Joseph and Loeb in Birmingham, Alabama, spread across the alley to the roof of the downtown telephone building which housed a switchboard serving some 8,000 stations, the long distance switchboard and positions handling information and other special services. The volume of water required to extinguish the fire in the roof and attic damaged the telephone equipment to such an extent that it was necessary to abandon this location for telephone service. The rapid restoration of toll service and of service to the 8,000 subscribers formerly served by the ruined office was an accomplishment of which the Bell System may well be proud, and it is hoped in the near future to include in the BELL TELEPHONE QUARTERLY an interesting description, by the Chief Engineer of the Southern Bell Telephone and Telegraph Company, of the way in which this problem, somewhat different from that encountered at Anderson, Indiana, as described above, was handled.

Owners of the Bell System

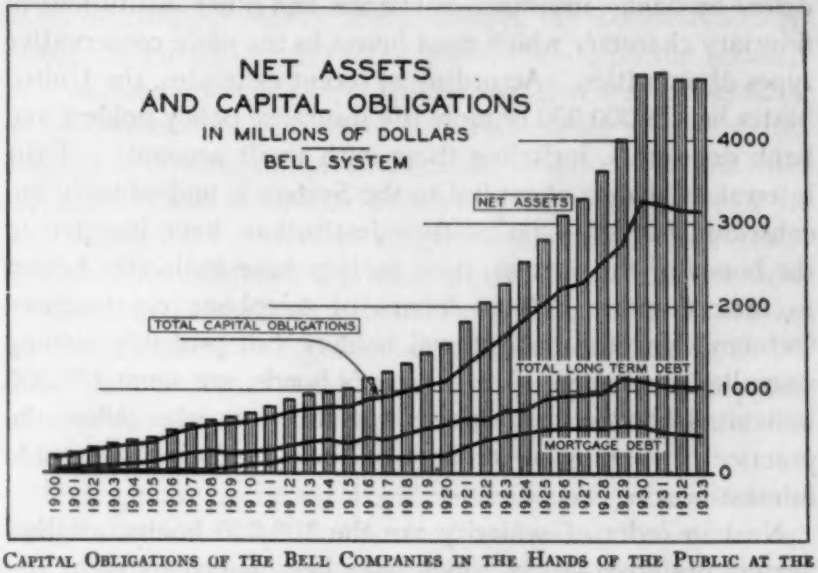
THE owners of the Bell System and their families, if they could be drawn together into a single community, would make up a city larger than Philadelphia. Fifty-eight years ago, however, when the first telephone was demonstrated at the Philadelphia Centennial, a skeptical public considered it a toy and few aside from the inventor saw any promise of public value in this new device.

By force of vision and private initiative, the small beginnings in the laboratory of Alexander Graham Bell evolved years later into a great national telephone system. This system, linking together more than 16,600,000 telephones throughout the United States, is now regarded as essential to the business and social welfare of the country. Certainly life could not go on at the present tempo without the telephone at our command.

A unified system such as is provided by the American Telephone and Telegraph Company and its Associated and Connecting Companies is as necessary to the nation as a common language. About 90 per cent of this telephone network is owned and operated by the companies comprising the Bell System; and through facilities which the Bell System provides for telephone communication with foreign countries, most of the world's telephones can now be reached from Bell-owned and Bell-connecting telephones. Thus the direct business descendants of the founders of the enterprise continue mainly responsible for the nation's telephone service.

The building of the Bell System covers a period of more than half a century, and at the present time nearly five billion dollars of investment are devoted to furnishing its telephone service. This construction of plant has been financed largely by issues of capital stock and bonds of the parent company of

the System, that is, by the American Telephone and Telegraph Company; but a number of its 24 Associated Companies, each of which operates the local and interurban telephone lines in one or more states throughout the country, have also sold securities to the investing public.



CAPITAL OBLIGATIONS OF THE BELL COMPANIES IN THE HANDS OF THE PUBLIC AT THE END OF 1933 WERE ONLY TWO-THIRDS OF THE TOTAL ASSETS.

At the end of 1933 the capital obligations of the Bell System were held by some 850,000 investors. A general classification of these investors according to type of security held is given below:

	Security Holders	Par Value Held	Average Holding
Bell System Bonds	180,000*	$ 921,200,600	$5,100
Associated Company Preferred Stock	108,000	97,937,600	900
Associated Company Common Stock	33,000	133,147,700	4,000
A. T. & T. Stock	681,000	1,866,227,500	2,700
Total Bell System	1,002,000	$3,018,513,400	$3,000
Total excluding estimated duplications in holders	850,000	$3,018,513,400	$3,500

* Estimated

Thoroughly American in character, this investment ownership represents a true cross-section of the nation—the average citizenry in home and office, in workshop and on the farm, seeking to invest in a safe, productive enterprise.

The outstanding bonds of the System are owned to a large extent by banks, insurance companies and other institutions of fiduciary character which must invest in the more conservative types of securities. According to recent estimates, the United States has 25,000,000 or more life insurance policy holders and bank depositors, including those with thrift accounts. Their interest as lenders of capital to the System is undoubtedly unconscious, but in so far as their institutions have invested in the bonds of the System, their savings have indirectly helped to finance many million dollars of telephone construction. Outnumbering the institutional holders, but probably owning a smaller proportion of the System's bonds, are some 170,000 individual bondholders representing investors who follow the practice of keeping all or part of their funds in high grade interest-bearing securities.

Next in order of seniority are the 108,000 holders of Bell System preferred stocks which have been issued by eight Associated Companies. Sold for the most part since 1921 to investors in the operating areas of the respective issuing companies, and with average ownership at the low figure of but nine shares per holder, these preferred issues are widely held by people of moderate means.

Although the A. T. & T. Co. owns nine-tenths of the common stock of its Associated Operating Companies, there are five of these companies which have some of their common stock outstanding in the hands of investors. The origin of this stock dates back to the earlier days of the telephone industry and, like the preferred stocks, such amounts of these issues as are outstanding in the hands of the public are held largely by investors in the territories of their respective companies. Some

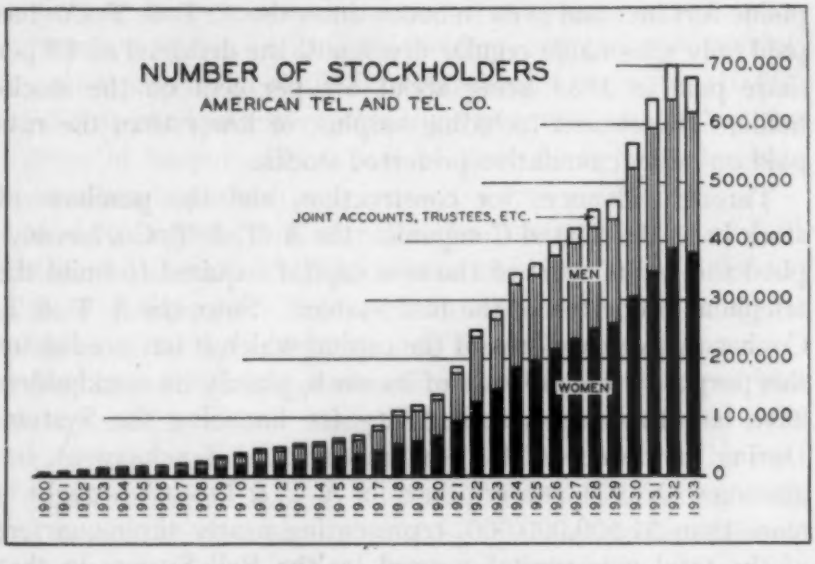
33,000 investors hold $133,000,000 par value of such common stock, with an average holding of 40 shares.

A. T. & T. stock represents in large measure the stock of the telephone industry of the nation. There are 18,662,275 shares of this stock outstanding and it is all of one class with a par value of $100 per share. For this stock the Company has received an average of $114 per share, making it the opposite of "watered" stock. It is interesting that but one-quarter of one per cent of the shares now outstanding represents the original interest of the inventor of the telephone and his three associates who launched the enterprise, excluding the stock for which they later subscribed on equal terms with other stockholders. Speculatively or otherwise, there have been no telephone fortunes and even in boom times the A. T. & T. Co. has paid only reasonable regular dividends, the dividend of $9 per share paid in 1933 being about 6½ per cent on the stockholders' investment including surplus, or lower than the rate paid on many cumulative preferred stocks.

Through advances for construction, and the purchase of stock in its Associated Companies, the A. T. & T. Co. has supplied the greater part of the new capital required to build the telephone properties of the Bell System. Since the A. T. & T. Co. has raised four-fifths of the capital which it has needed for this purpose through issues of its stock, plainly its stockholders have had the chief responsibility for financing the System. During the decade of the System's greatest development, beginning with 1921, subscriptions for A. T. & T. stock brought in more than $1,600,000,000, representing nearly three-quarters of the total new capital secured by the Bell System in that period.

According to usual security terminology, bonds and notes are underlying securities, preferred stocks rank next and common stock ranks as the junior, or equity, security. From the standpoint of raising new capital, this order must be reversed. In other words, common stock is the foundation upon which

all sound financing must be based, and the investment merits of this security largely control the success of future capital issues. Companies which are able to finance their needs with proper amounts of common stock are obviously in the best position to continue to raise new capital as required and to borrow money on favorable terms. Thus, the contribution which A. T. & T. stockholders have made toward financing the System's growth has been of fundamental importance to the nation's telephone users, for without the new capital provided by these hundreds of thousands of people it would have been impracticable to provide telephone service of the present scope or standard of convenience.



At the End of 1933 There Were 681,000 Stockholders with an Average Ownership of 27 Shares Each.

For the most part these stockholders are men and women who by their daily thrift have put aside small sums for investment, and thousands of them are now past their earning years. Based on an analysis made some time ago of 88,000 purchasers

of stock through a plan offered by the Bell Telephone Securities Company, it is estimated that stockholders fall into approximately the following occupational groups:

ESTIMATED DISTRIBUTION OF A. T. & T. STOCKHOLDERS BY OCCUPATIONAL GROUPS
DEC. 31, 1933

Bell System employees	115,000
Professional and technical	40,000
Educational	25,000
Clerks and sales people	90,000
Merchants	35,000
Trades and farming	25,000
Manual laborers	30,000
Management and financial	25,000
Government employees	15,000
Personal services	25,000
Retired	21,000
Housewives	210,000
Total individuals	656,000
Trustees	20,000
Corporations and private firms	5,000
Total A. T. & T. stockholders	681,000

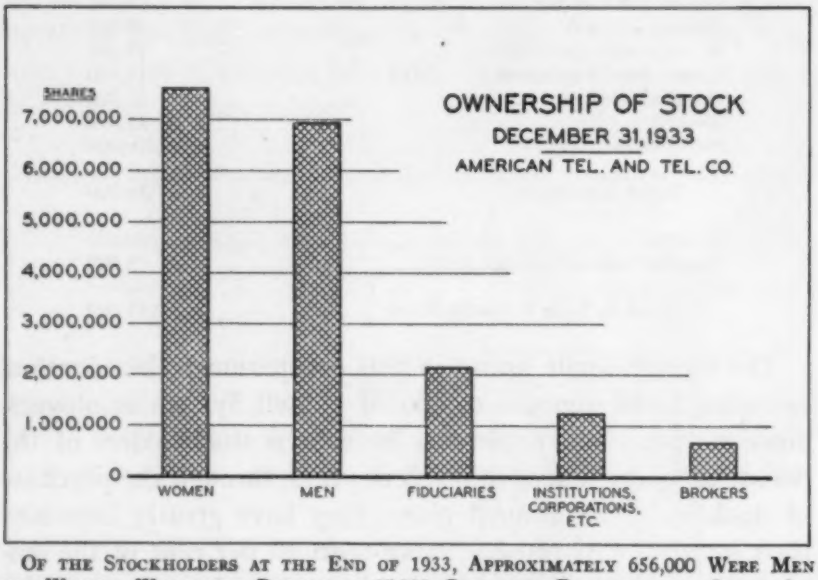
The largest single group in this occupational classification, excluding housewives, is composed of Bell System employees. Since its inception, employees have been stockholders of the parent company, but within recent years, through the purchase of stock under installment plans, they have greatly increased their interest. At present, more than 40 per cent of the employees own A. T. & T. stock and have thus chosen to put part of their savings into their own industry.

Some 20,000 trustees, executors and similar fiduciaries are registered stockholders. While their average holdings are only 74 shares each, they hold seven per cent of the stock. Banks and trust companies own an additional four per cent for others, perhaps chiefly for trust estates, which means that in all more than $200,000,000 par value of the stock is held in a fiduciary capacity.

About 5,000 institutions and corporations own A. T. & T. stock and the par value of their investment is more than $100,-

000,000. That this amounts to a substantial contribution from such sources to the stock financing of the System is obvious, but the character of these stockholders is of particular interest. Included in their number are 500 churches and religious organizations, 250 schools and colleges, 200 institutional homes and 150 hospitals.

Brokers' holdings of A. T. & T. stock have always been relatively small. At present, the list discloses about 490 broker-



OF THE STOCKHOLDERS AT THE END OF 1933, APPROXIMATELY 656,000 WERE MEN AND WOMEN, WHILE THE REMAINING 25,000 COMPRISED FIDUCIARY AND OTHER ACCOUNTS.

age firms with less than 3.7 per cent of the outstanding stock registered in their names. Although this represents, in a general way, the floating supply of the stock, actually it is smaller than this percentage indicates, for there is always a considerable amount of stock in brokers' names which is not in the market for sale.

At times of heavy stock financing, security dealers have been important factors in stabilizing the market and in absorbing through their market purchases the portion of each

new stock offer for which other stockholders have not subscribed. These new stock issues have not been underwritten in any way, but in the six offers made by the A. T. &. T. Co. from 1921 to 1930, brokers voluntarily bought subscription rights in the market from stockholders not wishing or able to subscribe, and thus with the rights they themselves received as stockholders they purchased a total of $191,000,000 par value of new stock. This sum which brokers subscribed for stock, in part for their clients, constituted 20 per cent of the total stock subscription under these offers and demonstrates the value to the telephone industry of having a stock which maintains its investment position.

There are, of course, a number of individuals who hold large amounts of A. T. & T. stock. For over forty years, however, no individual or small group has owned a controlling or even a relatively substantial interest in the stock of the A. T. & T. Co. or its predecessor, and now no individual stockholder has as much as one-fifth of one per cent of the stock outstanding.

Geographically, A. T. & T. stock is perhaps the most widely held single investment in the world. During earlier years the ownership of stock was naturally centered in Massachusetts, where the telephone was invented and first financed, but as the Bell System grew and its nation-wide character became established, interest in its securities extended to all parts of the United States. Furthermore, it was soon recognized that the telephone industry could not be financed through the savings of any one section of the country and that a broad interest in the Bell System would be needed to provide the capital funds required for its growth. There are now twelve states which each have more than 10,000 stockholders. Twenty-three states have more than 5,000 stockholders and no state has less than 500. There are 8,000 stockholders, or 1.2 per cent of the stock list, owning 2.7 per cent of the total stock, in 82 foreign countries and United States possessions.

Whiie farming areas and small centers of population have

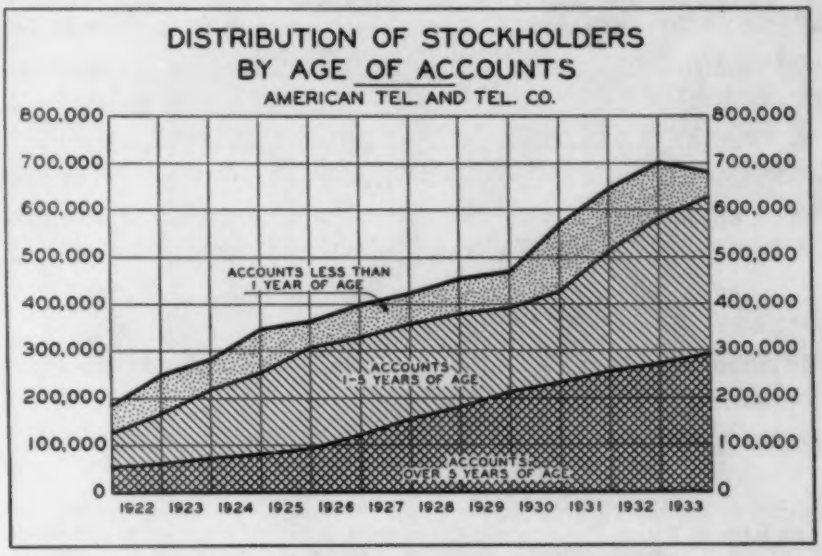
done their part in supplying the capital needs of the telephone business, there is also a wide distribution of the stock in cities. In fact, the ten largest cities of the United States account for a total of 200,000 holders. New York City alone has some 80,000 individual owners of the stock, or one owner for every 60 adult persons as compared with one owner for every 100 adults in the United States as a whole. Conservative estimates indicate that the total number of all people holding corporate stock in the United States is about 5,000,000. If this is true, about one in seven of these owns A. T. & T. stock.

From the first, a large proportion of stockholders have individually owned but a small number of shares. At present, owners of 25 shares or less comprise 80 per cent of the stock list, and some 260,000 of the stockholders, representing 40 per cent of the total, own five shares or less. As a result of this widespread ownership of stock in small holdings, there is an unusual democracy of interest in the business which, on the one hand, relieves the Company from possible dominance by small groups of stockholders and, on the other hand, provides a broad base for financing future capital needs.

Investors who have been able to buy only a small number of shares at a time have, none the less, had a vital part in new financing. By and large, these stockholders have taken more than their pro rata quota of new stock offered for subscription and since 1921, $200,000,000, or more than one-fifth of the total amount received under these offers, has been provided through subscriptions for five shares or less.

In any large investment list there is, of course, a continual turnover in individual holders. Death and the distribution of estates is an ever present factor in this turnover and in the case of the A. T. & T. Co. some 5,500 stockholder accounts are closed out yearly through this cause alone. Allied with this is the turnover due to gifts of stock to others. But there is a greater turnover due to the selling of stock by stockholders because they need funds or are attracted by some other in-

vestment. From the standpoint of these potential sellers, it is desirable that the stock have a ready market and that it be not subject to abnormal fluctuation. It is this very fluctuation in price, however, that unsettles and constantly works out of the list another and perhaps less numerous group of stockholders—those who are not well established in their savings habits—who are watching the market for current profits, or who may be uneasy about their investments in the face of day-to-day market developments.

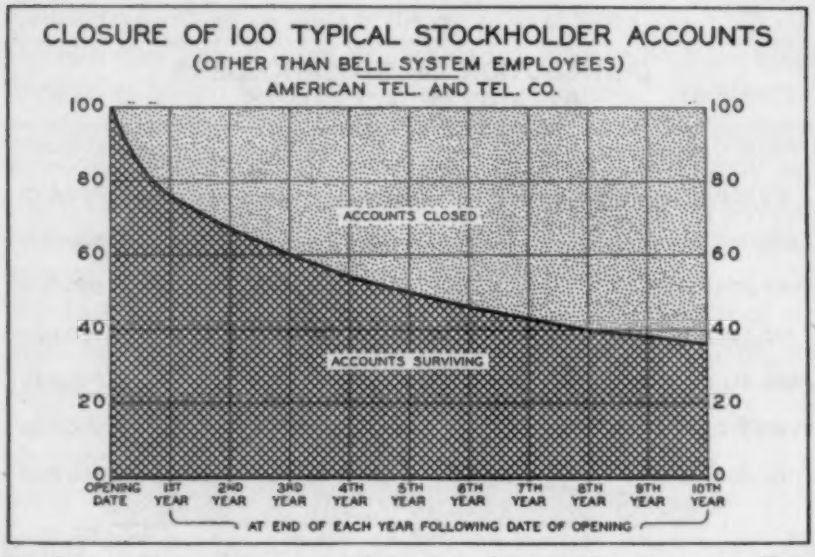


More than 43 Per Cent of A. T. & T. Stockholders Have Held their Stock for Five Years or More.

As a consequence of all these factors, there is a fairly consistent "mortality" rate among shareholders. The rate declines, however, as they become more seasoned. For example, about one stockholder in four is found to have closed out by the end of a year, whereas in the second year only one in every eight of those surviving will have closed out, with generally lower rates of loss thereafter.

These rates represent only average tendencies, however, be-

cause the actual turnover definitely varies from year to year under the impact of influences other than the mere composite age of the shareholders' accounts. For instance, the movement in prices has a quite noticeable effect on account closures, the tendency being for closure rates to increase when market prices are rising, as in the first nine months of 1929 when the gross closure in stockholder accounts rose to 15 per cent of the list. Compared with this experience, the gross loss for the



THE RATE AT WHICH STOCKHOLDERS CLOSE THEIR ACCOUNTS DECLINES AS THE YEARS PASS AND THEIR SAVINGS BECOME MORE STABILIZED.

same months of 1933 was less than 10 per cent, in part because the list was then more largely composed of seasoned holders.

In turnover, the holdings of women are noticeably more stable than the holdings of men. In 1933, the closure in the accounts of men amounted to 16 per cent of the average number of men holding stock during the year, whereas the closure in the case of women stockholders was only a little over nine per cent. This fact of more rapid turnover in men holders explains in some measure why women holders now outnumber

men by approximately 140,000, although their average holdings are less than those of men.

Because there is an inevitable "mortality" in stockholders, either the remaining holders must continuously stay in the market and increase their holdings or new investors must be attracted to the business. In either case it is necessary for the protection of stockholders and for the good of the System's credit that its securities should remain in healthy demand at all times, with willing purchasers available at reasonable prices. There is no other way to assure either the financial integrity of the business or an economically sound ratio between the amount of capital furnished by stockholders and funds loaned by bondholders. It is also essential that A. T. & T. stock, as the principal security of the System, should be held as an investment and not as a speculation. Speculative interests, whose first thoughts are for market profit, are transitory and incompatible with that long-range planning so important to an enterprise bound up with the public interest.

Regardless of its wishes in the matter, no company can prevent its stock from being subject to fluctuations in market prices under the impact of changes in the political or economic scene. While these changes in price may be disturbing to some investors, nevertheless they are a necessary consequence of a free security market. That there should be such a free market in A. T. & T. stock is almost axiomatic, since there is no person or group of persons with sufficient financial resources or foreknowledge of events who could determine where prices should be pegged. The Company feels that wide fluctuations in price are regrettable, but it feels more strongly that it should not attempt to influence or control the market, believing not only that it should not interfere, but also that an open market where all the various influences of investment opinion can have free play is the best kind of market place for stockholders to have when they desire to increase or decrease their holdings

or to know how current events are affecting their investment interests.

The Bell System has striven for leadership in keeping stockholders and the public well-informed about its aims and operations; and it seeks to accomplish this result at minimum cost through regular quarterly and annual reports, through press releases and booklets descriptive of the business, and through advertisements and other recognized media for giving out information and attracting interest.

Just as the System believes that its business contacts with the public should be flexible and individual in character in order to provide the best service to telephone users, so also it seeks to maintain its contacts with stockholders on a warm personal basis. Correspondence and telephone calls from stockholders are welcomed and thoughtful attention is given to their individual inquiries. There is one question which stockholders sometimes ask that the Company cannot answer: it cannot attempt to advise about the future course of market prices or whether A. T. & T. stock should be bought or sold at any current level. Of course, stockholders are keenly interested in safeguarding their investment funds, and when they see reports or rumors in the newspapers concerning the telephone business, nothing is more natural than for them to turn to the Company for advice about the possible effect of the rumored developments on their shareholdings. In answer to such inquiries the Company can give pertinent facts about its business in the way of earnings, past results, and operating policies, but it cannot know enough of an individual's situation to give him special investment advice and, above all, it cannot foretell the future course of market prices.

It must be recognized that A. T. & T. stockholders are the equity owners of the Bell System and that it is they who are carrying the ultimate risks of the business. Continuously conscious of this fact, the Bell System has fortified the position of stockholders by every practical safeguard of conserva-

tive finance; it cheerfully follows the most rigorous rules of trusteeship; and by research and experimentation it is constantly improving the telephone art so that its service to the public may be the best and most modern that science can provide and at the lowest cost that will insure fair compensation to the employees and owners of the business. The best assurance that these million or more people have as to the future success of the Bell System lies in the record it has made to date for sound management and enlightened public service.

C. S. VAN CISE

International Radio Telephone Circuits

IN an article in the BELL TELEPHONE QUARTERLY for July, 1930, entitled "World-Wide Telephony," reference was made to plans of the Bell System for the establishment of radio telephone facilities on the Pacific Coast through which service would be extended to the Hawaiian Islands, the Philippine Islands, and possibly to Australia and to countries of the Far East.

These facilities are now in operation and are being used to provide telephone service to the Hawaiian Islands, to the Island of Luzon in the Philippine group, and to Bandoeng, Java. There have also been established facilities near Miami, Florida, extending circuits to Central America, to some northerly situated South American countries, and to islands in the Caribbean. With the previously established stations on the Atlantic seaboard, the Bell System is now provided with stations on the three seaboards of the United States for overseas service by radio telephony, and it is thus in a position, without additional major expenditures, readily to extend its overseas services.

The radio facilities on the Pacific Coast were installed in 1931, the transmitter at Dixon and the corresponding receiver at Point Reyes, both in California. Provision is made for the co-ordinated operation of the transmitter and receiver at the long distance telephone office in San Francisco. In December of 1932, connection was established to the Hawaiian Islands, and in March, 1933, to the Island of Luzon in the Philippine group. In February of this year, a direct circuit was opened to Bandoeng, Java, and tests are now under way looking to the possible provision of a circuit to Japan. Negotiations are also under way for the establishment of a direct radio telephone circuit to Australia.

INTERNATIONAL RADIO TELEPHONE CIRCUITS

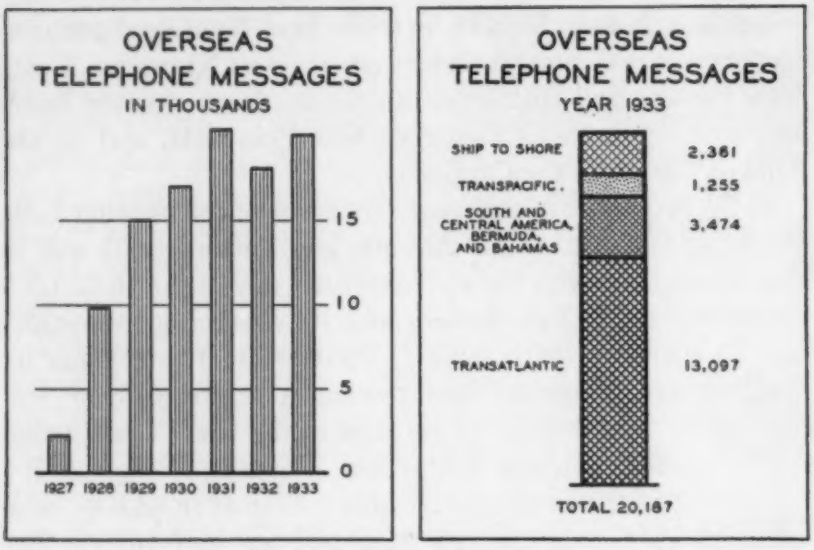
A radio telephone circuit to the Island of Bermuda was opened late in 1931, using the facilities at Lawrenceville and Netcong in New Jersey. The radio telephone terminals established near Miami, Florida, in 1932 have been used for connections to the Central American countries of Nicaragua, Costa Rica, Panama and Guatemala, to the northerly situated South American countries of Columbia and Venezuela, and to the Bahama Islands in the Caribbean.

At the beginning of this year, by means of the existing radio telephone facilities on the Atlantic and Pacific coasts and in Florida, together with the wire networks, any of the 16,600,000 telephones of the Bell System and its connecting companies may be connected with some 13,000,000 other telephones located in fifty countries and territories scattered over five continents. At present, 92 per cent of the world's telephones can be reached from any Bell System telephone.

The rest of the world has also been diligent in adding radio telephone circuits in the last three and one-half years. The map and list which follow this article show the existing and proposed international radio telephone circuits of the world at the beginning of the year 1934, amounting to 66 circuits in service, comprising about 250,000 circuit miles. The map included with the article of July, 1930, showed but 15 existing circuits with a total of little over 75,000 circuit miles. All of the circuits opened during recent years have utilized short waves.

On the Atlantic seaboard, ship-to-shore radio telephone service of the Bell System with ocean-going vessels has grown rapidly since its establishment in 1929. The transmitting and receiving stations for this service are at Ocean Gate and Forked River, New Jersey. Since December of 1929, when the service was opened with the Leviathan, it has been extended to 19 additional ships: Majestic, Olympic, Homeric, Empress of Britain, Europa, Hamburg, Rex, Conte di Savoia, Aquitania, Ile de France, Monarch of Bermuda, Queen of Bermuda,

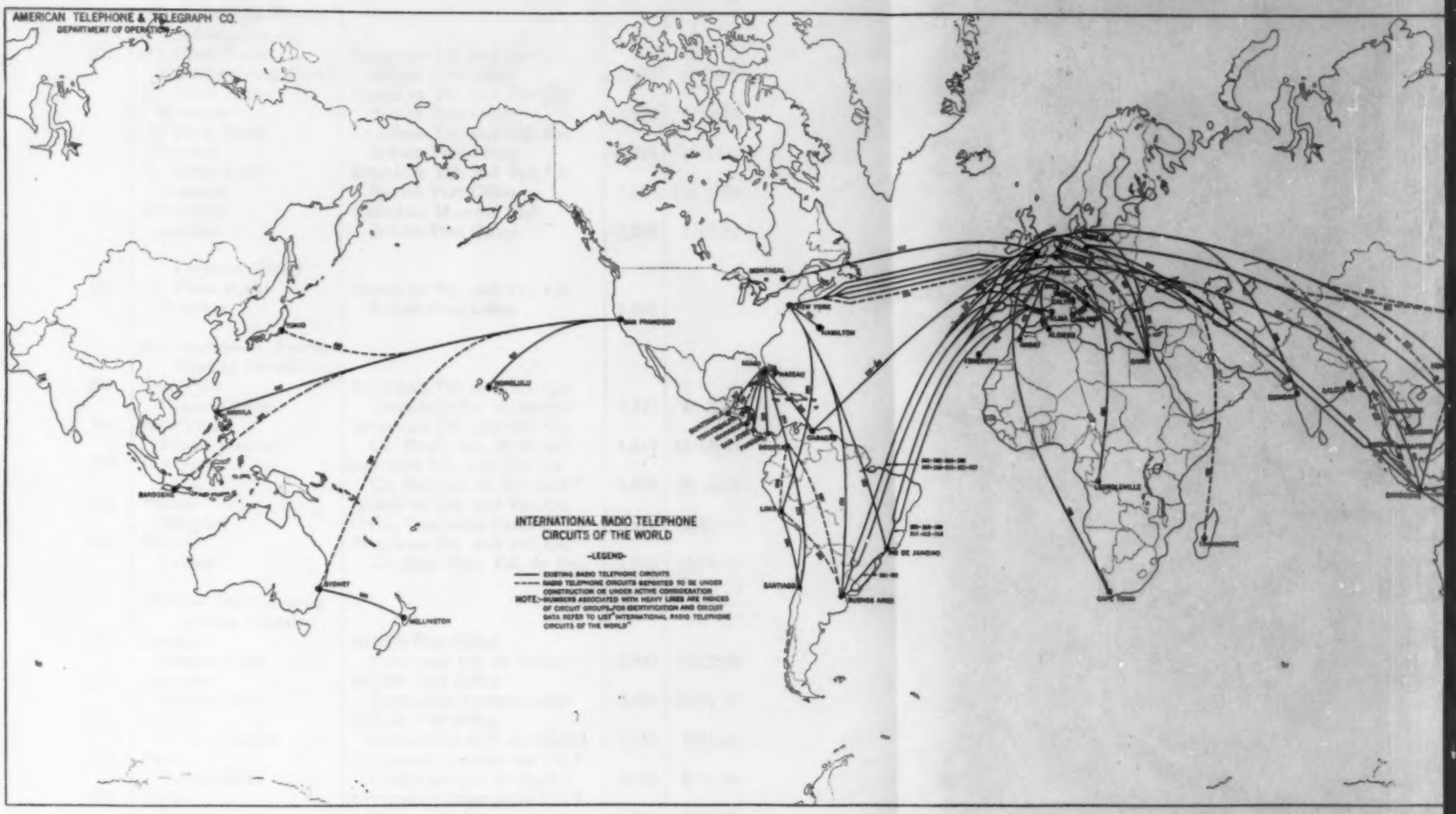
Deutschland, Bremen, Albert Ballin, New York, Columbus, Caledonia and Berengaria.



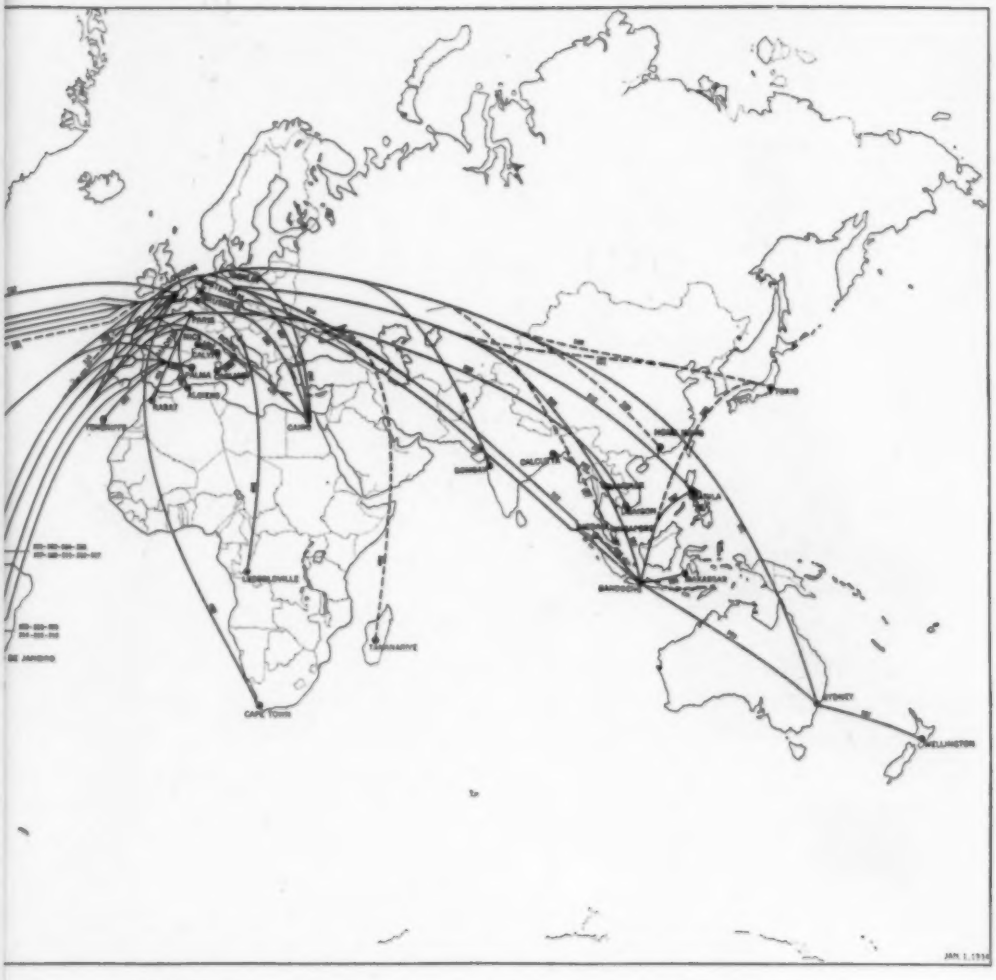
These Two Charts Show the Overseas Telephone Messages Handled Through the Transmitting and Receiving Stations of the American Telephone and Telegraph Company.

The overseas telephone messages of the Bell System are shown graphically in the accompanying charts taken from the Annual Report of the American Telephone and Telegraph Company for the year 1933.

Elam Miller



MAP SHOWING THE INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934. A TABULATION OF THESE CIRCUITS BEGINS ON THE OPP



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INTERNATIONAL RADIO TELEPHONE CIRCUITS

INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934

Circuit Group	Circuit Terminals	Ownership	Statute Miles	Service Date
	North America–Europe Existing Circuits			
101	(1) †New York– †London (Long Wave)	American Tel. and Tel. Co. British Post Office	3,448	1/ 7/27
	(2) †New York– †London	American Tel. and Tel. Co. British Post Office	3,448	6/ 6/28
	(3) †New York– London	American Tel. and Tel. Co. British Post Office	3,448	6/ 1/29
	(4) †New York– †London	American Tel. and Tel. Co. British Post Office	3,448	12/ 1/29
102	†Montreal– London	Canadian Marconi Ltd. British Post Office	3,245	7/11/32
	Proposed Circuit			
101	(5) †New York– †London	American Tel. and Tel. Co. British Post Office	3,448	
	No. America–So. America Existing Circuits			
201	New York– †Buenos Aires	American Tel. and Tel. Co. Compania Int. de Radio*	5,327	4/ 3/30
202	New York– Rio de Janeiro	American Tel. and Tel. Co. Co. Radio Int. do Brasil*	4,849	12/18/31
203	New York– Lima	American Tel. and Tel. Co. Co. Peruana de Tel. Ltd.*	3,679	10/14/32
204	Miami– †Bogota	American Tel. and Tel. Co. Co. Telefonica Central	1,514	12/22/32
205	Miami– Caracas	American Tel. and Tel. Co. Co. Ann. Nac. Tel. de Ven.	1,362	12/19/32
	Europe–South America Existing Circuits			
301	London– Buenos Aires	British Post Office Compania Int. de Radio*	6,921	12/12/30
302	London– Buenos Aires	British Post Office Transradio Internacional	6,921	12/12/30
303	London– Rio de Janeiro	British Post Office Companhia R.T. Brasileira	5,769	5/21/31
304	Paris– Buenos Aires	Companie Generale de T.S.F. Compania Int. de Radio*	6,868	6/11/30
305	Paris– Buenos Aires	Companie Generale de T.S.F. Transradio Internacional	6,868	2/ 1/29
306	Paris– Rio de Janeiro	Companie Generale de T.S.F. Companhia R.T. Brasileira	5,695	3/31/30
307	Berlin– Buenos Aires	German Post Office Compania Int. de Radio*	7,406	9/10/30
308	Berlin– Buenos Aires	German Post Office Transradio Internacional	7,406	12/10/28

INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934
(*Continued*)

Circuit Group	Circuit Terminals	Ownership	Statute Miles	Service Date
	Europe–South America Existing Circuits (Cont'd)			
309	Berlin– Rio de Janeiro	German Post Office Companhia R.T. Brasileira	6,230	3/21/30
310	Berlin– Caracas	German Post Office Co. Ann. Nac. Tel. de Ven.	5,150	9/13/31
311	Madrid– Buenos Aires	Co. Tel. Nac. de Espana* Compania Int. de Radio*	6,248	10/12/29
312	Madrid– Buenos Aires	Compania Transradio Espanola Transradio Internacional	6,248	/ /29
314	Madrid– Rio de Janeiro	Compania Transradio Espanola Companhia R.T. Brasileira	5,057	/ /30
315	Madrid– Rio de Janeiro	Co. Tel. Nac. de Espana* Co. Radio Int. do Brasil*	5,057	1/28/32
317	Rome– Buenos Aires	Italo Radio Transradio Internacional	6,930	12/ 1/31
318	Rome– Rio de Janeiro	Italo Radio Companhia R.T. Brasileira	5,713	10/28/31
319	Madrid– Caracas	Co. Tel. Nac. de Espana* Co. Ann. Nac. Tel. de Ven.	4,355	12/19/32
320	Paris– Caracas	Companie Generale de T.S.F. Co. Ann. Nac. Tel. de Ven.	4,740	7/24/33
	Proposed Circuit			
316	Brussels– Buenos Aires	Belgium Government Transradio Internacional	7,028	
	Europe–Africa Existing Circuits			
401	Paris– †Rabat	Companie Generale de T.S.F. Moroccan T. and T. Admin.	1,132	11/ 3/30
402	Madrid– †Teneriffe	Co. Tel. Nac. de Espana* Co. Tel. Nac. de Espana*	1,128	1/22/31
403	London– †Capetown	British Post Office Overseas Com. Co. of S.A.	6,011	2/ 1/32
404	London– Cairo	British Post Office Marconi R.T. of Egypt	2,179	6/22/32
405	†Paris– †Algiers	French P.T.T. French P.T.T.	836	6/ 6/33
406	†Brussels– †Leopoldville	Belgium Government Belgium Government	3,893	9/15/32
407	Berlin– Cairo	German Post Office Marconi R.T. of Egypt	1,808	7/22/32
409	Paris– Cairo	Companie Generale de T.S.F. Marconi R.T. of Egypt	1,993	11/ 1/32
410	Rome– Cairo	Italo Radio Marconi R.T. of Egypt	1,328	12/20/32

INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934
(*Continued*)

Circuit Group	Circuit Terminals	Ownership	Statute Miles	Service Date
	Europe–Africa			
	Proposed Circuit			
408	Paris–	French P.T.T.		
	Tananarive	French P.T.T.	5,488	
	Europe–Asia–Oceania			
	Existing Circuits			
501	London–	British Post Office		
	Sydney	Amal. Wireless Australasia	10,557	4/30/30
502	(1) †Amsterdam–	Netherlands Government		
	Bandoeng	Neth. Indies Tel. Admin.	7,294	1/ 8/29
	(2) †Amsterdam–	Netherlands Government		
	Bandoeng	Neth. Indies Tel. Admin.	7,294	12/ 1/29
503	Paris–	Companie Generale de T.S.F.		
	†Saigon	Companie Generale de T.S.F.	6,298	4/11/30
504	Berlin–	German Post Office		
	Bandoeng	Neth. Indies Tel. Admin.	6,726	12/27/29
505	Berlin–	German Post Office		
	Bankok	Siamese Government	5,349	4/15/31
506	London–	British Post Office		
	†Bombay	Indian R.T. Co.	4,545	5/ 1/33
510	Berlin–	German Post Office		
	Manila	Phil. L.D. Telephone Co.	6,124	3/ 1/33
	Proposed Circuits			
507	London–	British Post Office		
	Singapore	Imp. and Int. Comm. Ltd.	7,694	
508	London–	British Post Office		
	Tokio	Japanese Government	5,941	
509	London–	British Post Office		
	Hong Kong	Hong Kong Tel. Co.	5,979	
511	Berlin–	German Post Office		
	Tokio	Japanese Government	5,532	
	No. America–Asia–Oceania			
	Existing Circuits			
601	San Francisco–	American Tel. and Tel. Co.		
	†Honolulu	Mutual Telephone Co.	2,393	12/23/31
602	San Francisco–	American Tel. and Tel. Co.		
	Manila	Phil. L.D. Telephone Co.	6,969	3/30/33
	Proposed Circuits			
603	San Francisco–	American Tel. and Tel. Co.		
	Tokio	Japanese Government	5,133	
604	San Francisco–	American Tel. and Tel. Co.		
	Sydney	Australian Post Office	7,425	

INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934
(*Continued*)

Circuit Group	Circuit Terminals	Ownership	Statute Miles	Service Date
	No. America–Asia–Oceania Proposed Ciccuits(Cont'd)			
605	San Francisco– Bandoeng	American Tel. and Tel. Co. Neth. Indies Tel. Admin.	9,101	
	North America Existing Circuits			
701	†New York– †Hamilton (Bermuda)	American Tel. and Tel. Co. Imp. and Int. Comm. Ltd.	795	12/21/31
703	Miami– †Managua (Nicaragua)	American Tel. and Tel. Co. Tropical R.T. Co.	1,002	6/ 7/33
704	Miami– †San Jose (Costa Rica)	American Tel. and Tel. Co. Tropical R.T. Co.	1,120	3/20/33
705	Miami– †Panama	American Tel. and Tel. Co. Tropical R.T. Co.	1,161	2/24/33
706	†Miami– †Nassau	American Tel. and Tel. Co. Bahamas Government	175	12/16/32
707	Miami– †Guatemala	American Tel. and Tel. Co. Tropical R.T. Co.	1,017	4/17/33
	Proposed Circuit			
702	Miami– †Tegucigalpa (Honduras)	American Tel. and Tel. Co. Tropical R.T. Co.	919	
	South America Existing Circuits			
801	Buenos Aires– Rio de Janeiro	Transradio Internacional Companhia R.T. Brasileira	1,227	/ /31
802	Buenos Aires– Rio de Janeiro	Compania Int. de Radio* Co. Radio Int. do Brasil*	1,227	12/12/31
803	†Bogota– Santiago	All American Cables, Inc.* Co. Int. de Radio S.A.*	2,644	8/ 1/31
804	Lima– Santiago	Co. Peruana de Tel. Ltd.* Co. Int. de Radio S.A.*	1,537	12/15/32
	Proposed Circuits			
805	Lima– Bogota	Co. Peruana de Tel. Ltd.* All American Cables, Inc.*	1,166	
806	Lima– Buenos Aires	Co. Peruana de Tel. Ltd.* Compania Int. de Radio*	1,952	
807	Bogota– Buenos Aires	All American Cables, Inc.* Compania Int. de Radio*	2,902	
	Asia–Oceania Existing Circuits			
901	Sydney– Wellington	Australian Post Office New Zealand Government	1,375	11/25/30

INTERNATIONAL RADIO TELEPHONE CIRCUITS OF THE WORLD AS OF JANUARY 1, 1934
(*Continued*)

Circuit Group	Circuit Terminals	Ownership	Statute Miles	Service Date
	Asia–Oceania			
	Existing Circuits (Cont'd)			
902	Bandoeng– Bankok	Neth. Indies Tel. Admin. Siamese Government	1,469	4/15/31
903	Bandoeng– Sydney	Neth. Indies Tel. Admin. Australian Post Office	3,392	12/23/30
904	Bandoeng– †Medan (Sumatra)	Neth. Indies Tel. Admin. Neth. Indies Tel. Admin.	875	9/16/31
906	Bandoeng– †Makassar (Celebes)	Neth. Indies Tel. Admin. Neth. Indies Tel. Admin.	854	7/ 1/33
907	Bandoeng– Manila	Neth. Indies Tel. Admin. Phil. L.D. Telephone Co.	1,742	2/23/33
	Proposed Circuits			
905	Bankok– Calcutta	Siamese Government Indian Radio Company	1,008	
908	Bandoeng– Tokio	Neth. Indies Tel. Admin. Japanese Government	3,609	
	Europe			
	Existing Circuits			
1001	Madrid– †Palma (Majorca)	Co. Tel. Nac. de Espana* Co. Tel. Nac. de Espana*	330	10/24/31
1002	†Nice– †Calvi (Corsica)	French P.T.T. French P.T.T.	105	6/ 1/32
1003	Rome– Cagliari (Sardinia)	Azienda di Stato Ser. Tel. Azienda di Stato Ser. Tel.	257	/ /32

* Indicates International Tel. and Tel. Co. subsidiary or affiliate.
† Indicates terminal does not share time with other circuits.

Notes on Recent Occurrences

DIRECT RADIO TELEPHONE CIRCUIT LINKS UNITED STATES AND JAVA

A DIRECT radio telephone circuit between San Francisco and Java, in the Dutch East Indies, was opened on February 1. Service over the new channel is available to all Bell and Bell-connecting telephones in the United States, Canada, Cuba and Mexico, and at the other end it reaches not only Java but Sumatra.

Prior to the opening of the new circuit, telephone communication between the United States and the Dutch East Indies was maintained by way of New York, London and Amsterdam. From the west coast of the United States the total length of the older circuit was 14,500 miles, made up of two radio channels and 3,600 miles of land lines. The length of the new channel is 8,700 miles. It is the longest radio circuit operated by the American Telephone and Telegraph Company, being twice as long as those between New York and London and over 1,700 miles longer than the circuit now in service between San Francisco and Manila.

The new service is maintained through the short wave radio telephone stations of the American Telephone and Telegraph Company in California, which for some time have handled the service to Hawaii and the Philippines. The transmitting station is at Dixon, near Sacramento, and the receiving station at Point Reyes, just north of San Francisco.

The cost of a call between Java and any point on the Pacific coast is $30 for the first three minutes and $10 for each additional minute. To other points in the United States, Canada, Cuba and Mexico the rates are proportionately higher.

DR. JEWETT ELECTED A TRUSTEE OF CARNEGIE INSTITUTION

DR. FRANK B. JEWETT, vice president of the American Telephone and Telegraph Company and president of the Bell Telephone Laboratories, was elected a member of the Board of Trustees of the Carnegie Institution of Washington on December 15, 1933.

"SIGNALS AND SPEECH IN ELECTRICAL COMMUNICATION"

FROM the pen of John Mills, member of the technical staff of Bell Telephone Laboratories, has come a book designed for readers who would like a clear non-technical introduction to the mysteries and complexities of electrical communication. Under the title "Signals and Speech in Electrical Communication," the book presents the philosophy of the electrical transmission of intelligence, the general principles for communication by wire and by radio.

Sixteen short chapters, written in a semi-technical manner and free from mathematics and diagrams, present readable and interesting explanations of dial switching, telephone repeaters, multi-channel transmission systems and transoceanic communication. The engineering achievements in the allied fields of sound pictures, broadcasting, television and stereophonic reproduction are also explained.

In the chapter entitled "The Vivisection of Speech" are explained the complexities of human speech, and the method of "scrambling" speech which is undertaken for privacy in radiotelephone conversation. Under the title "The First War with Attenuation" the author traces the romantic history of transcontinental telephony, and in "The Modern Jinn" he describes how the electrons in a vacuum tube play their part in the mar-

vels of telephony. The chapter on "The Natural Limits" tells the limitation which nature imposes upon the efforts of communication engineers. The chapter which deals with dial telephone switching, "Communication with Electrical Brains," appeared as a separate article in the January issue of the BELL TELEPHONE QUARTERLY while the book was on the press of Harcourt, Brace and Company, its publishers.